SCIENTIFIC AMERICAN SUPPLEMENT No. 640

Scientific American Supplement, Vol. XXV., No. 640.
Scientific American, established 1845.

NEW YORK, APRIL 7, 1888.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE LARTIGUE RAILWAY IN KERRY.

CHEAP and light railways have often been recommended for the benefit of some agricultural districts in Ireland. On Feb. 29, a new single-rail line of ten miles, from Listowel to Ballybunion, in North Kerry, was opened by the directors with a party of invited visitors. These included Lord Ventry, Lord Bessborough, Mr. H. Monro, chairman of the Lartigue Railway Construction Company, Mr. F. B. Behr, managing director of the line, Mr. Colhoun, traffic manager, Great Southern and Western Railway, M. Chapron, representing the French Minister of Marine and the Colonies, and several ladies. On the journey to Ballybunion Mr. Behr explained the working of the line and the system adopted.

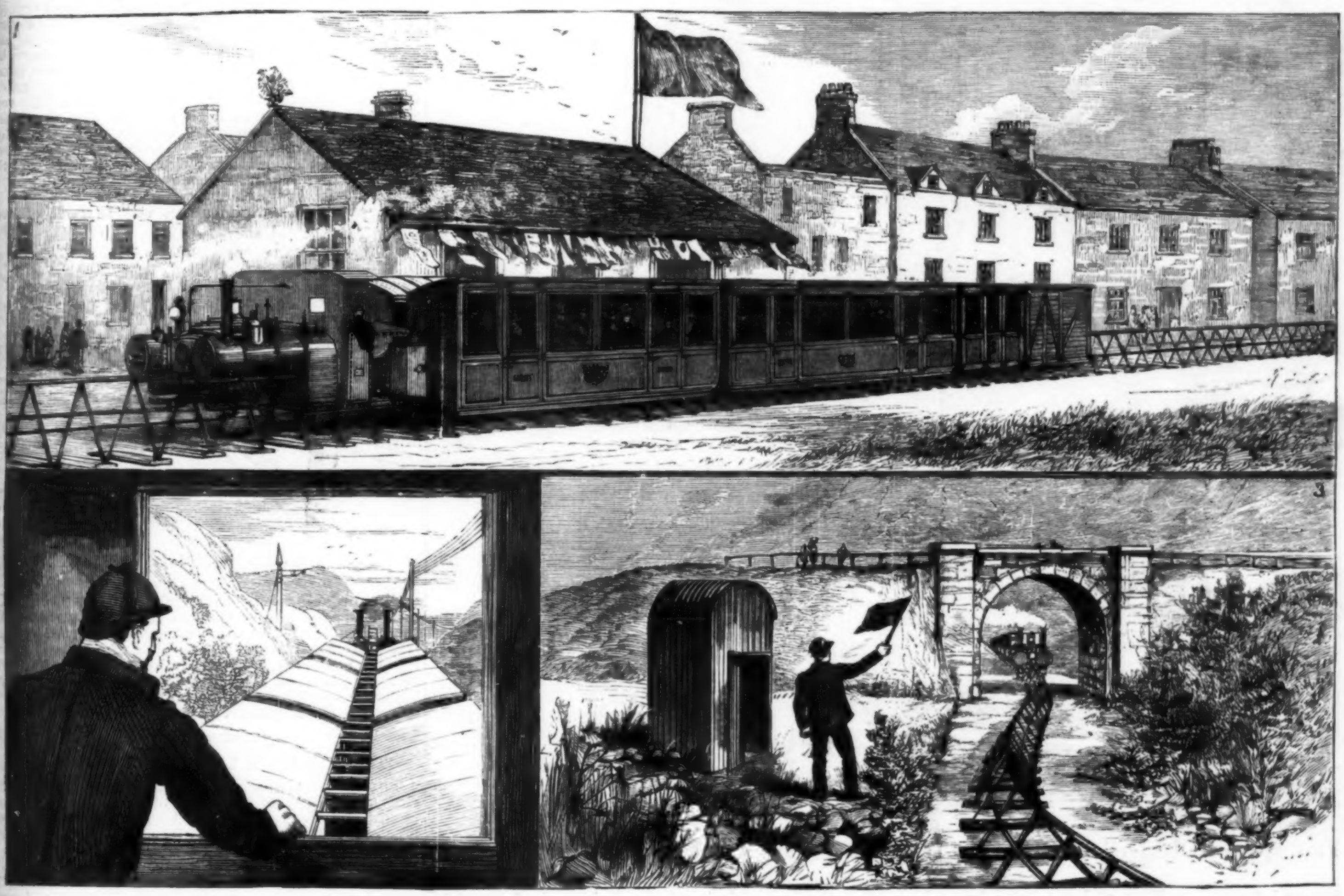
This is what is known as the Lartigue single-line system, the motive power being steam. It differs from the only other single-line Irish railway, between Portrush and the Giant's Causeway, which is worked by electricity. The single steel line is at an elevation of 3½ ft. from the ground. It is supported by trestle-shaped steel bars attached to sleepers of the same material, strengthened by wood in soft or boggy places. The side bars are about 4 ft. apart, and the line proper presents the appearance of a series of isosceles triangles, rather than a railway as ordinarily understood. Along the bars at each side the rails for the guide wheels of the locomotives and rolling stock are placed about a foot from the ground; the latter rails assist in steadying the oscillation of the train when in motion. The switching is done by eccentric turn-tables fitted with a curved portion of the rail; the public road level crossings by a portion of the line are made to swing back on a pivot when required. In some cases crossings are effected by a wooden drawbridge raised or lowered by winches to the level of the top rail. When the traffic has passed over the drawbridge, the latter is raised by pulling the chain, which is securely fastened. The working of the machinery of itself regulates the signals. The engines are fitted with two separate horizontal boilers and provided with tenders fitted with cylinders and machinery which allows the surplus steam to be used on steep inclines for additional motive power. The wheels on which the locomotives run are in the central space, between the boilers; they are 22 inches in diameter.

The new line is now working for traffic, having been sanctioned by Major-General Hutchinson, Inspector for the Board of Trade. The cost of the line, including everything in the shape of material and stocks, has been at the rate of £3,000 per mile. With regard to the anticipated traffic, the managing director, Mr. Behr, estimates it at from £80 to £100 per week gross. This will be in the main derived from excursionists to Ballybunion in the summer months, and the carrying of sea sand from that place, largely used by the farmers of Kerry for top dressing and manuring their lands. The line has been constructed without any guarantee, and will help to develop the resources of the district.—*Illustrated London News.*

LISTOWEL AND BALLYBUNION RAILWAY, COUNTY KERRY, IRELAND.

THIS railway was incorporated by special act of Parliament, toward the close of the session of 1886. The actual construction of the line was begun toward the end of July, 1887, but was interrupted for several months by difficulties which arose in securing the land. Though a number of railways on the Lartigue single rail system have been built in several countries for agricultural, mineral, and industrial purposes, they have all been worked up to the present either by electricity or by animal power. The Listowel and Ballybunion Railway is the first line built on this system worked by locomotives, and designed for carrying a general mixed traffic of passengers and all classes of goods, such as any ordinary railway would have to carry. For this reason many difficulties naturally arose during the construction in matters of detail. The railway, which is about ten miles long, was completed in less than five months from the date when the whole of the land was secured. The position of the line is not well chosen for the purpose of displaying the particular advantages of the Lartigue system, but it was decided to build it in preference to any other because it was the first line on this system authorized by act of Parliament, and the persons interested in proving the usefulness and advantages of the system were desirous to lose no time in doing so. The line, unfortunately, had been laid out for an ordinary narrow gauge railway, and closely follows alongside a public road, passing through deep bogs and bad ground generally. It was not possible to deviate the line, as it was necessary to maintain it within the Parliamentary limits, thereby giving no opportunities of choosing the best ground for this system or applying its power of using sharp curves and following the natural undulations of the country, as ought to be done wherever it is possible. This also impeded the facility of drainage, which is one of its principal features, and created difficulties with regard to the very numerous level crossings, which are necessary for the accommodation of farmers and others. These difficulties could easily have been avoided by removing the railway a certain distance from the public road.

The line, as at present built, has a length of about ten miles, with maximum gradients of 1 in 50, which occur in many places. The rolling stock consists of three engines, which we illustrate, with two horizontal boilers each, provided with tenders of a novel construction. These tenders are fitted with cylinders and a special gear, which allows the surplus steam of the engines to be used on steep inclines in order to give additional power and adhesion to the engines. This gear is so arranged that it can be instantaneously applied by the engine driver by simply turning a wheel without in any way interfering with the working of the train, and keeping it in full motion while he is applying the steam to the tender. The engines were built by the Hunslet Engine Company. They weigh, when in full working order, six and a half tons, and the tenders, in full working order, weigh about four and a quarter tons. It is calculated that there is sufficient steam in the boilers to use the additional cylinders on the tenders for runs not exceeding one mile. The engines are worked with a maximum pressure of 150 lb. The carriages and goods wagons, illustrated in Figs. 2 and 3, have been built by the Falcon Engine and Car Works, Loughborough. They consist of three first and four third class passenger carriages, about 16 ft. long without the buffers, and about 8 ft. wide, and accommodating from twenty to twenty-four passengers. The interior arrangements are of two different kinds, viz., some are made so as to seat passengers with their backs to the rail, and others are made to seat them in the ordinary way, facing each other. There are also two covered goods vans, two guards' vans, to which third class coupes are attached, two open goods wagons, two cattle trucks, convertible into trucks to carry sheep and pigs by insert-



1. Terminus of the line at Ballybunion. 2. Top of the train, viewed from guard's van. 3. Signalman at his box.

THE LARTIGUE SINGLE-LINE RAILWAY BETWEEN LISTOWEL AND BALLYBUNION, KERRY.

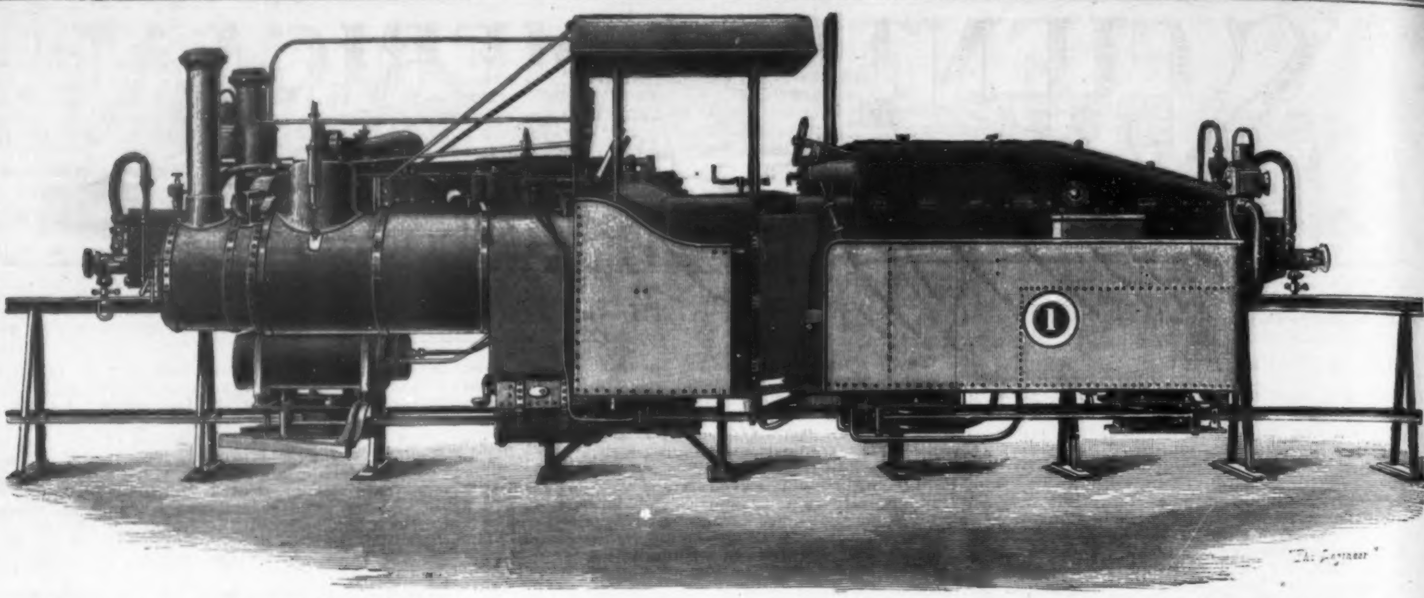
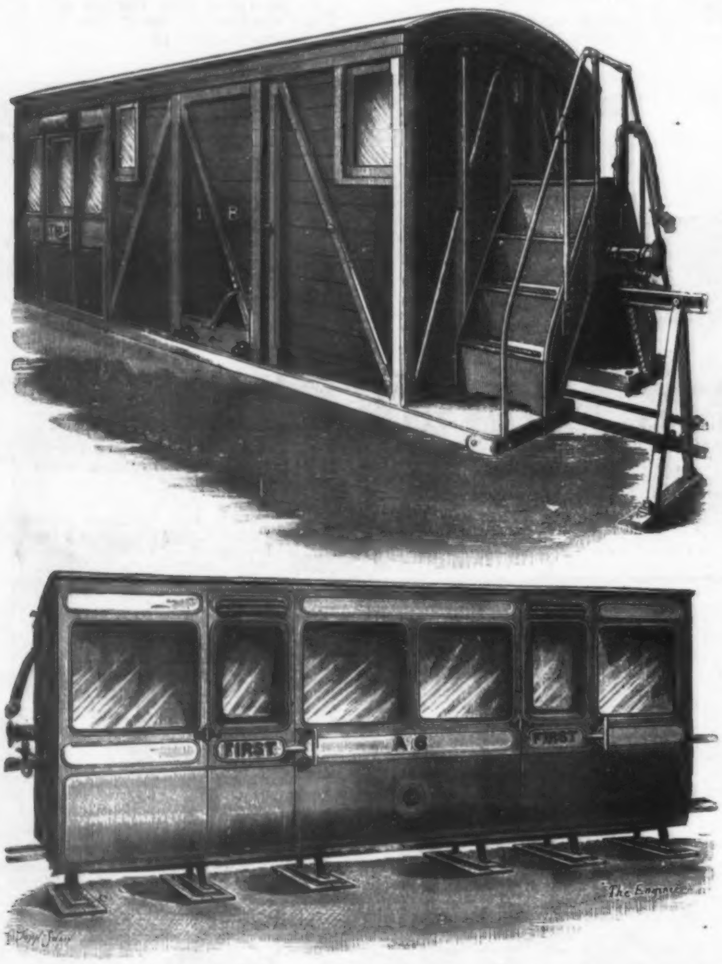


FIG. 1.—LOCOMOTIVE ENGINE, LARTIGUE SYSTEM, LISTOWEL AND BALLYBUNION RAILWAY.



FIGS. 2, 3.—ROLLING STOCK, LISTOWEL AND BALLYBUNION RAILWAY.

ing an intermediate floor, and one horse box, with a third class coupe attached.

All these trucks and wagons are of the same length as the passenger carriages, but they are 9 ft. wide. The framework is the same in all these carriages and wagons, as well as the wheels and side wheels, so that every part is absolutely interchangeable.

The wagons carry each four tons of goods. There are also two little platform carriages with steps to cross over the line, which can be attached midway between the carriages of each train, and the guards' vans are also fitted with steps for the same purpose. Besides the above rolling stock there are twenty sand trucks, each capable of carrying four tons. These trucks were made at the works of M. Achille Legrand, Mons, Belgium. They are also fitted with the same wheels and buffers as the remainder of the rolling stock, but they are only about 7 ft. long by 6 ft. 6 in. wide. The engines and passenger carriages, as well as the goods vans, are fitted with the Westinghouse brake, and the remainder of the rolling stock is fitted with the connecting pipes of this brake, so as to be able to have a continuous system of the Westinghouse brake working on any mixed train of passengers and goods.

The switches are of peculiar construction. The diagram, Fig. 4, shows one in plan, while Fig. 5 gives the details. They are really eccentric turntables fitted with a curved portion of the rail, so as to be able to switch on to a number of lines wherever such a turntable switch is placed. They are about 25 ft. in diameter, and the radius of the curves is 98 ft. The turntable is constructed on the same principle, only that the piece of line fitted on to it is a straight line, and that the turntable is concentric instead of eccentric. The turntables are about 25 ft. in diameter, and will allow of an engine and tender being turned without difficulty.

The occupation level crossings are of two kinds: One in the shape of a drawbridge, which is raised and lowered on to the level of the top rail by special winches, so that the road traffic passes over the top rail when the gates are lowered, and, after the traffic has passed over it, they are raised by simply pulling the chain, giving free passage to the trains. The other occupation level crossings are constructed by making a piece of line into the shape of a gate, turning on a pivot and locked by patent locks, which compel the farmers, before opening the gap in the line, to close the field gates, and before opening the field gates to close the gap in the line. These level crossings are all fitted with very complete signals, which show to the engine driver at a distance if the level crossings are in a position to allow the train to pass with safety. The public road level crossings are all constructed by making a portion of the line move on a pivot, and each of these crossings is, of course, in the charge of a gatekeeper.

The whole of the permanent way is made of steel,

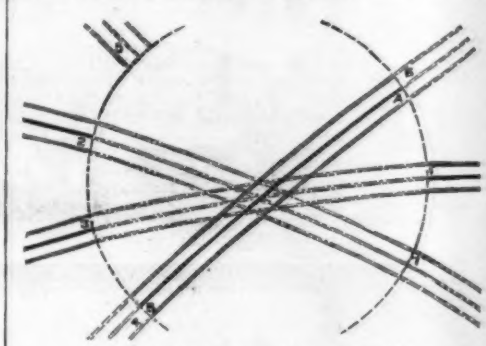


FIG. 4.—DIAGRAM OF SWITCH.

and manufactured at the works of Mons. Achille Legrand. It consists of the top rail and two side rails for the guide wheels of the carriages connected by angle irons forming a trestle in the shape of a capital A resting on a sleeper, which is in some parts of the line laid on planks 6 ft. long, 9 in. wide, and 3 in. thick. This was specially required on the very boggy and soft ground.—*The Engineer.*

FIG. 5.—LISTOWEL AND BALLYBUNION RAILWAY—DETAILS.

THE SIX INCH LONGRIDGE WIRE GUN.

The first wire gun constructed entirely on Mr. Longridge's principle by Admiral Kolokoltzoff, at the Abouchoff steel works, has just been successfully tested. The gun is 35 calibers long, with a powder chamber 6·84 in. diameter, and weighs 5·6 tons. The inner tube is of steel, with 85 in. of its breech end strengthened with steel wire incased in a cast iron jacket on which the trunnions are formed, and which carries a breech mechanism of the De Bange type. The wire, weighing 1,656 lb., is 0·252 in. wide by 0·059 in. thick, was wound on in an ordinary lathe by means of an automatic apparatus constructed by Messrs. Easton & Anderson, and attached to the saddle of the ordinary slide rest. Up to the present time the following rounds have been

fired, in the presence of many naval and military men interested in gunnery:

Number of rounds.	Weight of shot.	Weight of powder.	Muzzle velocity.	Pressure in atmospheres.
	lb.	lb.	ft.	
7	72	27 to 38	—	—
10	72	39½	2150	2947
11	90	"	1937	2952
163	122	"	1715	3250

Five hundred rounds in all are to be fired. The success of the gun is perfect, and completely justifies Mr. Longridge's contention that trustworthy ordnance can be constructed cheaply, and, above all, very quickly, on his system.

ESTRADE'S HIGH SPEED ROLLING STOCK.

THE administration has just authorized a trial of Mr. Estrade's high speed rolling stock on the state line of railways. Let us briefly recall the fact that this stock, conceived by its inventor on exceptional principles, consists of a locomotive, a tender, and a car, provided with wheels 8 ft. in diameter. The three axles of the wheels are connected, and the inventor thinks that by making the diameter of the wheels the same he will avoid certain retarding effects, and, in current service, attain a speed of at least 78 miles an hour. The experiments, which will be awaited by the professional corps of the railways with great curiosity, will show what can be done in this respect, and also will permit of studying, under new conditions, the disturbing effects due to the difference of the position of the center of gravity in locomotives.

The locomotive under consideration, which has been named the Parisienne, is 32 ft. in length and 4 ft. in width between sole bars. Its firebox has a surface of 136 square yards, and its boiler holds 880 gallons of water.

The weight of the engine, empty, is 38 tons, and loaded, about 42 tons. The rolling stock reached the state line, where the experiments are to be made, through the Orleans company's line. As the works of the builder, Mr. Boulet, are not connected with any railway, the locomotive had to be carried through Paris on a special car used by the Cail establishment for such purposes.

The car, which is built strongly of wood and iron, is easily capable of carrying loads of from 50 to 60 tons. The wheels are of cast iron, and, in order to prevent the formation of ruts, are 24 inches in width. The car was hauled by 45 horses placed three abreast. At one time it was feared that the street pavements and the macadamized roadbed of the boulevards might not be everywhere in a state to support so exceptional a load; but these fears proved groundless, the only damage done being limited to the slight sinking of a few paving stones.—*Le Genie Civil.*

HAULING THE HIGH-SPEED LOCOMOTIVE THROUGH PARIS.

[Continued from SUPPLEMENT, No. 639, page 10203.]

HEATING CITIES BY STEAM.*

By CHARLES E. EMERY, Ph.D.

CONSIDERABLE investigation has been necessary to perfect a meter which would answer all the conditions to be fulfilled in measuring steam. It is evident that if a displacement meter were used, the cylinder development would necessarily equal the piston development, calculated to the points of cut-off of the engines supplied through it. For ordinary slide valve engines, therefore, the meters would have to be practically as large as the engines, or run at very much higher speeds, subject to all the difficulties incident to so doing. A small three cylinder engine has been developed for use where very small quantities of steam are required, it being expected to pass the steam at full pressure through the meter, and then reduce the pressure afterward, thus measuring only at the greatest density and the smallest volume. The conditions of use in the district now supplied require, however, another form, yet to be described.

Experiments have been made with meters of the velocimeter type, in which the velocity of the current of steam is registered by a series of indices. Mr. Birdsall Holly designed an instrument of this kind, in which the current of steam struck one edge of a series of floats, like those of a paddle wheel. The jet was controlled by a clapper falling by gravity to reduce the opening to a narrow slit, through which steam passed to strike the wheel, when the quantity of steam passing through was limited. The axis of the paddle wheel was made vertical, and upon the lower end of the shaft was a resistance paddle wheel, which worked in water of condensation collected in the bottom of the case. The steam escaped freely from an opening between the two wheels.

This meter has precisely the same kind of variations as any other velocimeter. When passing small quantities of fluid, the slip is very large, and the record is against the supply company. For quantities which may be called moderate to considerable, relative to the size of meter, the rate is remarkably near uniform, when everything is in order. When run to the full capacity of the pipe, the meters are not so accurate. The difficulty with this class of meters lies in keeping the friction constant and preventing wear. There must be some means of carrying the motion of the paddle wheel outside of the case. This is done by driving the axle, which passes through the stuffing box, at reduced speed, by means of gearing inside the case. Notwithstanding this, however, the stuffing box soon gets leaky. The speed of the wheel is quite high, and the bearings wear down rapidly, so that it can safely be stated that the apparatus is not a desirable one for use, except at comparatively low pressures and moderate velocities.

The speaker, at an early date, made up his mind that a successful meter must be based on the principle of flow through an orifice of known size, and with a known loss of head or difference of pressure. Several methods of doing this were tested. In the meter finally adopted, called a "rate meter," the steam flows through rectangular openings, governed by a valve, operated by a weighted piston, balanced on the difference of pressure between the incoming and outgoing steam, the effect of which is that the steam flows through the orifice at a constant difference of pressure. The size of the orifice is regularly registered on a broad paper strip, traversed by clockwork. The result is a diagram showing at any time in the day the quantity of steam used at that time, and the total quantity may be obtained by integrating the chart. When steam is not used, the movable pencil runs on the same line with a stationary one. The paper upon which the meter record is made is printed in divisions of one half an inch, numbered from one to twenty-four consecutively, to represent the hours of the day, and in starting the paper, the proper division is set at the corresponding time.

The time that steam is turned on is shown by the vertical line made by the movable pencil at the beginning of the diagram, and when it is shut off by a similar line at the end. And evidently the periods when any particular change is made in the quantity of steam used can be determined from the meter diagrams, as well as the quantity used during the intervals. It was at first considered unfortunate that a reliable meter could not be obtained, which, like a water meter, would show by differences of reading the quantity of steam used for the interval between observations directly without calculation, and without the expense of maintaining a time register at each location, and of integrating the charts afterward.

This system, however, proved a blessing in disguise. The greatest difficulty in settling with consumers lies in the fact that employes waste the steam. This is particularly the case during the heating season, when steam for various uses is left on continuously during nights and Sundays, thus increasing the time of consumption from, say, sixty hours a week to 168 hours. In many cases, too, the rate of consumption keeps uniform during the night as well as during the day, so that it is an easy matter to more than double the bills. The consumers at first naturally lay the blame to the steam of the steam company, but the meter charts have been the means of enabling the company to satisfy consumers when, and to what extent, the increased bills were due to mismanagement on their premises.

The meters and regulating valves are placed in the pipes leading from the streets to the building, and arranged with shut-off and pass-by valves, so that any part of the apparatus may be put in order without stopping the supply of steam to the building.

[The lecturer then described a watchman's tell-tale system, in which a valve in the pipe leading to the consumer was connected electrically with a watchman's box on the exterior of the building.]

The watchman, being provided with a suitable recording apparatus on his person, visited the several boxes in succession, and by sending an electrical impulse from a portable battery through the watchman's box into the valve, received in turn a record which could be interpreted at the office to show whether or not the valve was open. This apparatus was used while suitable meters were being devised and perfected. [Plans were also shown of the station "B" boiler house of the company.] At that station it was necessary to erect boilers of 16,000 horse power on an irregularly shaped plat, seventy-five feet in width, and on an average less than 120 feet deep. To obtain proper floor room, the boilers were arranged in four tiers, each tier in a separate story twenty feet high, besides which the plans provide for a fifth story for coal storage and a basement for miscellaneous uses. Each floor is arranged for sixteen boilers of 250 horse power each, which are placed in two rows, to face a central fire room. There are two chimneys, located between the boilers on the sides of the fire room, as near the center of the building as the shape of the plat permitted.

The whole capacity of the building not being needed at first, the walls were only carried up to an elevation of eighty-eight feet eight inches, and a temporary roof applied, so that at present there are available only three stories for boilers, and one above for coal storage. The south chimney has been practically completed. The north one was originally extended just above the temporary roof, covered and connected with the other by a sheet iron casing. In the summer of 1885, it was thought desirable to examine the interior of the south chimney and make any necessary repairs to lining, etc., for which reason it was decided to top out the north chimney with a shaft of practically half the area, which would be sufficient for summer use, while the other chimney was being examined.

There are now in place in the building, and fully connected, forty-eight boilers, aggregating 12,000 horse power.

Customers were first supplied with steam in April, 1882, since which time the steam pressure has been maintained continuously day and night. The coal is brought from the dock in carts and wagons, and dumped from the rear street into small cars in the basement of the rear buildings. These cars are run back to the elevators, lifted to the top of the main building run out on tracks over coal bins and dumped, the coal descending by gravity through chutes in front of each alternate column, and flowing out as needed on the several fire room floors, close alongside the fronts of the boilers. The ashes pass from the ash pans down chutes in front of intermediate columns to cars in the basement. These cars are hoisted on the elevator to the roof of the rear building, run out on tracks to the front of that building, and the ashes dumped into a chute, from which they are loaded into carts on the street below.

The boilers are of the sectional type, manufactured by the Babcock & Wilcox Company.

From lack of room, a well established rule was necessarily disregarded, and the lower portions of the chimneys, instead of being independent, were made part of the building, the section of each being rectangular and corresponding closely to the floor space occupied by one of the boilers. Within the building, the outside of the chimney walls are vertical, the offsets due to reducing the thickness of walls upward being inside the flue. Above the roof the inside of flue is parallel, and the walls are decreased on the outside, each offset being marked by a belt of granite blocks, forming a water table.

The lining extends only to the roof line, and is put in in sections, supported on the internal offsets. The lower part of each chimney above the footings is 32 feet long outside and 13 feet wide. The flue at the top is 27 feet 10 inches long and 8 feet 4 inches wide. The chimneys are topped out at a height of 220 feet above high water, or 221 feet above their foundations. The tops of chimneys are, therefore, 201 feet above the grates of the lower tier of boilers, but only 141 feet above the grates of the upper tier of boilers.

The foundations of the walls of the building are at the elevation of mean high water, and the chimney and column foundations one foot below. An archway is provided through the base of each chimney, as a means of communication between different parts of the basement.

A fixed iron ladder is attached to each chimney, and connected at top with points and at bottom with a cable to form a lightning protector. It was designed to make the top of the south chimney with a projecting platform and iron reticulated balustrade, in which case the chimney would have been 232 feet above high

* A lecture delivered before the Franklin Institute, November 18, 18[illegible]. From the *Franklin Journal.*

water. It was hoped that by painting the balustrade prominently, it would give the effect of a capital to the shaft without the weight of actual surface projections. For various reasons, however, the top was finished with a granite coping at the elevation of 220 feet above high water, as previously stated, a simple footboard being provided about the chimney, with an iron hand rail secured in coping stones.

Although the chimney appears slender the narrow way, it is so supported as to have ample weight to resist the overturning moment caused by a wind pressure of fifty pounds per square foot on the area of one flat side.

The shaft erected on the retangular stump of the north chimney is octagonal in section, with one edge resting on a partition wall built in the center of the lower flue. The walls are reduced from the outside, with a stone water table at each offset. This chimney is provided with a cap constructed of wrought iron plates, supported on cast iron ribs built in the brickwork.

Main steam pipes, sixteen inches in diameter, are arranged in front of each row of boilers on each floor, and connected to two vertical drums, which are in turn connected in the basement to the street mains. By properly adjusting the valves provided, either set of boilers can be connected with or disconnected from either drum. The two drums on each Babcock & Wilcox boiler are yoked together near the rear of the boiler, and from the yoke a wrought iron pipe is carried nearly to the main pipe in front, but at a lower elevation, where it connects with a copper pipe nearly parallel with the main pipe about eight feet long, which latter connects with a combined stop and check valve on the main. This bent pipe enables the main connection from the boiler to expand freely. The valve at the connection to the main is a simple metal check, which the steam is obliged to raise in order to reach the main pipe, there being provided, however, a screw from the top which can be set down to hold the check in place and make it a stop valve. When the boiler is in use, the screw is run up, and the steam passes out through the check. This arrangement has the advantage that if any rupture occurs in one boiler, the steam and water only from that one boiler will be blown out, the check valve preventing the steam in the main pipe from entering.

In one case, by carelessness, water was allowed to get low in one boiler, and one of the headers was cracked. Through the crack water issued on the fire, suddenly generating a current of steam sufficient to blow the door open and force part of the fire out upon the floor. The steam and water practically put the fire out; the other boilers supplied the demand, so that there was no fluctuation in pressure observable on the recording gauge, nobody was hurt, and if there had been no person in the building, the boiler would have taken care of itself without doing injury of any kind whatever. It will be seen that had even this slight accident occurred with all the boilers in free communication, there would probably have been so much steam in the room that the stop valve could not have been shut until the steam pressure had dropped, and the consumers of the company been greatly annoyed.

The two drums enable steam to be taken to the street by two routes, so that leaks on either can be repaired during the night without interrupting the supply to the streets. This system of duplication was so important that what is called a donkey system was also put in; that is, there is another system of steam pipes extended around behind the boilers with a small connection from each. These pipes have two connections independent of the drums, to the main street pipes in front, and one section is connected to one of the drums.

The principal cause of accidents in the operation of large, long steam pipes, underground or otherwise, arises from collections of water in the mains, when the pipes are cold or there is no steam circulating. The system previously described, of draining the mains to low points, where the water is removed automatically by steam traps, in connection with the plan of maintaining the pressure continuously, absolutely prevents any serious accumulations of water in the mains of the New York Steam Company, when the same are in use. If, however, a main be shut off for making a large connection not originally provided for, for repairs or any other reason, intelligent care must be taken in restoring the pressure to prevent the pipes from being injured by what are termed "water rams." Any main which has been out of use for a considerable time is liable to have water in it from the leakage of steam past the connecting valves, and its condensation in the disused pipe. Again, when the main is shut off temporarily, water is likely to be introduced from the return mains through the service connections, particularly in winter, when the heating systems are connected. Check valves are put in the discharges of the traps to prevent this, but they are not always in order. To prevent the possibility of any water entering the steam main in this way, orders are given to shut off all the service connections before shutting off a main.

If steam be admitted at the top of a vessel partially filled with cold water, condensation will take place until the surface is somewhat heated, and this, in connection with a cloud which forms above the surface, will retard rapid condensation, so that in due time the full steam pressure can be maintained above water cold at the bottom. This phenomenon is not an infrequent occurrence in boilers in which the circulation is defective. It is, therefore, perfectly safe to heat up any vessel containing cold water, if the steam can be admitted from the top upon the surface of the water and so maintained. If, however, steam be blown in below the surface of the water, a bubble will be formed, which will increase in size until its surface becomes sufficiently extended to condense the steam more rapidly than it can enter, when a partial vacuum will be created, the bubble will collapse, and the water flowing in from all sides at high velocity will meet with a blow, forming what is called a water ram. In blowing a small quantity of steam into a large quantity of water, these explosions occur in the middle of the mass, and create simply a series of sharp noises. If, however, steam be blown into a large inclined pipe full of water, it will rise by difference of gravity to the top of the pipe, forming a bubble as previously stated, and when condensation takes place, the water below the bubble will rush up to fill the vacuum, giving a blow directly against the side of the pipe. As the water still further recedes, the bubble will get larger, and move farther and farther up the pipe, the blow each time increasing in intensity, for the reason that the steam has passed a larger mass of water, which is forced forward by the incoming steam to fill the vacuum.

The maximum effect generally takes place at a "dead end," as it is called, or where the end of the pipe is closed. Even if the water does not originally extend to the "dead end," if the pipe near it be once filled with steam which has bubbled through water on its way to that point, there may be sufficient cold metal to condense it, so that collapse will take place on the same principle as before, and the whole mass of water in the pipe be driven by the incoming current of steam against the end, sometimes with tremendous force, the effect being to cause leaks and sometimes rupture the pipe or break out the end connections. It is not necessary, either, that the end of the pipe be closed. In fact, under certain conditions, a more forcible blow is struck when the end of the pipe is open, as for instance when a pipe crowned upward is filled with water, one end being open and the steam introduced at the other, a bubble will in due time be formed at the top of crown, when the water will be forced in by atmospheric pressure from one end, and by steam pressure from the other, and the meeting of the two columns frequently ruptures the pipe. Evidently, too, the same action can occur without difficulty in a level pipe, but, as previously stated, cannot in a pipe which descends away from the entering steam, so that the latter is *always above* the water.

It is evident from the above that it is always desirable in turning steam on an inclined main to introduce it from the top and let the water out at the bottom of the slope. When this can be done, any workman can be trusted to attend to it. Frequently, however, there are undulations in the pipe, and at times mains which may contain water have to be heated by letting the steam in at the lower end. In buildings, the difficulty can, of course, be prevented by opening drip pipes at the lower end, and letting the water out before the steam is admitted. The same thing can be done with underground pipes, and provision for this should always form part of the plans when it is known that a pipe will have to be heated up in this way. In practice, however, a street system contains so very many absolutely necessary details, that a provision of this kind will not be originally provided for, and at times it will occur that a main which it was expected to heat from the top of a slope may, from something being out of order, necessarily be heated from the other direction. Difficulties also occur in small pipes where the extra labor and expense required to provide special drains for overcoming this difficulty would not be warranted, particularly as another solution of the difficulty is available, even with pipes of considerable size.

If a blow-off opening be provided at one end of a main to be filled with steam, even if such blow-off be at the higher end, and the steam be admitted at the lower end, any water in the main can be driven out of the blow pipe, provided the steam valve be opened sufficiently wide to keep the pressure continuously maintained against the water. The explanation of this is that if the steam supply be limited, the water will run back under portions of the steam, forming bubbles which may suddenly collapse and produce water rams; but if the steam supply be practically unlimited, or at least sufficient, the steam will force the column of water back along the bottom of the pipe, as any vacuum formed will be filled by the steam driving back the water. There will be a series of small explosions, which will scarcely be heard, and do no harm, and the seething wall of water will be continually forced forward and finally out of the pipe.

Note the distinction in the two methods of operation necessary to suit the conditions. When the steam is on top of the water, it may be turned on as slowly as desired, and it is better to turn it on slowly, as thereby the heavy castings are heated slowly and are not so liable to be strained; but when steam *must* be turned into the lower end of a descending pipe, which *may* be filled with water, the valve must be opened sufficiently to establish a definite current and keep up the pressure. This will not require the valve to be wide open, but the result will be substantially as though it were so open.

Practical engineers, who on sea and land have had to do with turning steam on in pipes, naturally recoil from turning steam on quickly in any pipe, and it is very hard to explain to them the difference. The writer has had to take a party of men of this kind, state the reasons for action, and in one case recollects using as an illustration that if a farmer with a pitchfork could get an officer on the run, the latter could not draw his sword, turn, and defend himself, as he would be run through before he came to close quarters. The principle applies to the water in an ascending pipe. The column of water once started, the steam, if the supply be made sufficient, follows it up so closely, and in such volume, that no condensation can take place sufficiently to stop the onward movement. The clearing of a pipe in this way requires nerve and judgment, but in one case considerable cold water was driven uphill out of a six inch pipe, 1,400 feet long, with a difference of elevation at the two ends of fully twenty feet, by letting steam in at the lower end and blowing the water out on the surface of the street through a two inch blow-off pipe. The blow-off pipes are made no larger than this, even for mains fifteen and sixteen inches in diameter, but it is not considered safe to attempt to clear an ascending main of this size with this size of blow-off pipe. All these mains are more nearly level, have blow-offs at low points, near the valves, and can be blown off by putting steam in at or near the summit. In heating up an eleven inch pipe, only 400 or 500 feet long from the bottom, the writer has had the flange taken off the extreme end, in order to give the water free exit and prevent the possibility of a ram.

The greatest drawback, in a commercial sense, affecting all systems for supplying a fluid under pressure to underground pipes, is leakage, with its direct loss of fluid, together with the expenses of inspection and repairs necessary in finding and stopping the leaks. Many gas companies in small cities and villages lose one-third the quantity of gas generated, by leakage. This proportion is generally reduced as the quantity sold is increased, but even old established companies in large cities lose ten per cent. in this way. Large quantities of water are also wasted in the extended distribution of towns and cities.

The work of the New York Steam Company was particularly well done, with the intention of reducing this loss to a minimum; still, to the surprise of all, the loss from this cause far exceeds that due to condensation. Of necessity, there are thousands of joints and many hundreds of valves with packed valve stems to the mile. If most of the valve stems and an occasional joint leaked but a trifle each, the loss in the aggregate would be comparatively large.

It is to be regretted that time has not permitted a more complete description of apparatus necessary in carrying out the principles involved in the transmission of steam and of the particular details of the work of the New York Steam Company. Nearly every one of the branches of the subject discussed could of itself be made the subject of a special lecture, full of detail, possessing more or less interest to those who might be called upon to engage in work of this class.

In closing the engineering view of the subject, it may be stated that all the problems are worked out, and that all details are mechanically successful; and, moreover, the returns on the very large investment of the New York Steam Company are sufficient to invite the attention of capital to new ventures of the same kind.

There is a field for another lecture in a popular view of the questions relating to the uses to which steam from the streets can be put, and the advantages of this method of supply. At this time, but a word can be given to this branch of the subject. It will be understood that steam engines of all kinds and sizes, in any location from cellar to garret, can be operated to drive shops, furnish electric light, pump water, and the like, and that heating, either by live or exhaust steam, can be done on any scale, but it is also true that nearly all the *cooking* of a family can be done by steam. Nothing is lacking, in fact, but sufficient temperature to brown bread and put the finishing touch, as it may be called, upon broiled meats. Meats may be cooked perfectly with steam heat, but they cannot, in the open air, be so highly heated as to give the particular aroma which pleases the taste. Meat of all kinds can be roasted in an oven jacketed with steam more perfectly than in one heated directly by fire, as the juices of the meat are kept in and, becoming heated, aid in cooking the entire mass evenly and thoroughly. Many large restaurants do all their roasting in steam ovens. Boiling of all kinds is very simply performed in jacketed kettles.

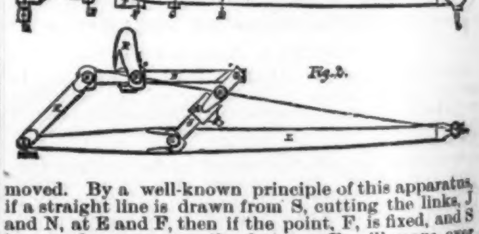
An attache of the New York Steam Company has recently made an invention whereby, by planing the top of a steam table and the bottoms of the vessels to be heated, and using simple clamps, stews can be made and water boiled in vessels not jacketed with steam; the heat being transmitted from below, and the rapidity of heating or violence of the ebullition controlled simply by tightening or loosening the clamps. With steam stoves fitted with these various devices, and having in connection therewith small gas stoves for finishing the broiling of meat, and perhaps gas attachments to the ovens to brown the bread and cake, housekeepers will be provided with a great boon. With the exceptions named, which do not form a large portion of the work, every operation can be performed by simply regulating a steam valve. By these means the objectionable features of handling coal and ashes will be entirely removed, and provision for doing most of the cooking, as well as complete facilities for heating water, and in winter for warming the building, be provided "on tap," so to speak, the same as gas and water.

Thus the sun's energy of ages past, stored in luxuriant vegetation and buried with it beneath debris due to cosmic changes, may now be redeemed from the bowels of the earth as coal, transmitted to a distance as steam, and bring sunlight to the household by lightening domestic labor. Power, heat and even actual light may be obtained and manufactures promoted in most inaccessible and contracted places; and one more subject is now available for the exercise of the talents of the engineers of the future, in their efforts to advance still further the comforts and civilization of mankind.

ENGRAVING MACHINE.

THIS machine is another adaptation of the pantograph, that prolific source of mechanical inventions. It is adapted for copying on metals, ivory, vulcanite, or glass; designs, letters, figures, etc., and for line dividing on straight, flat, beveled, or cylindrical surfaces.

In using the machine, the material to be engraved is clamped on the table, M, shown in the perspective view; the copy being placed at T, over which a style, S, attached to one arm of a pantograph (Fig. 2) is



moved. By a well-known principle of this apparatus, if a straight line is drawn from S, cutting the links, J and N, at E and F, then if the point, F, is fixed, and S is moved over any path whatever, E will move over an exactly similar one.

In the actual macnine, F is a saddle sliding on N, to any part of which it may be clamped, but working on centers in the carrier, P, which is rigidly attached to the frame of the machine. By the above arrangement the whole system of link work can rotate horizontally about F. At E there is a revolving drill, carried on the slider, K, which can be clamped on J so that F, E and S are in one straight line. This drill is driven by a treadle in the case of the machine illustrated, and rapidly cuts out in any article placed on the table, M, an exact copy of the path followed by the style, S. The copies used may be line drawings on paper, but preferably on metal, wood, or vulcanite. For simple let-

ter and figure work separate metal types are set in the table, T, similarly to printer's type.

The style is guided by the right hand of the operator, while the left regulates the depth of the cut by means of a milled nut on E, and by the use of a stop this depth can be kept constant if required. The cutter runs at a high speed and the section of the cut may be of any form—moulded, semicircular, beveled, rectangular, or even dovetailed. For engraving on finished brass work a simple flat double-edged drill gives a clean, brilliant cut, free from burr, which may be either left bright or colored by suitable solutions. When it is desired to fill the cut with wax, a long pointed drill is used, giving a cut with steep sides, and leaving the bottom of the cut sufficiently rough to hold the wax.

The mounting table, M, is capable of motion in all directions, and is fitted with a swivel joint for circular and beveled work. For circular dividing the worm-wheel shown in the perspective view is used, the number of teeth in which is suited to requirements, and where these are extensive changeable worms are adopted. Lines are worked by a simple point tool in the cutter spindle, the style being moved along fixed straight guides, and all lettering and figuring may be done at the same setting of the machine.

The machine was originally designed by Messrs. Taylor, of the Slate Street Works, Leicester, for engraving figures and letters on their photographic lenses and other scientific instruments, but has now been adapted to a great variety of work, including name plate engraving, stamp engraving, embossing seals, dies, and moulds, marking and numbering instruments and

IMPROVED ENGRAVING MACHINE

tools, dividing and engraving dials, scales for gauges and measuring instruments.

In addition to the above, the machine will do engine turning and profiling work, and by the use of suitable milling tools in conjunction with the dividing apparatus, wheel cutting and similar work may be executed.

From the above description it will be seen that the engraving is not of the same size as the pattern. In the machine illustrated, the size of the engraving may be varied from one-fourth to one-sixteenth that of the copy.—*Engineering.*

MANGANESE STEEL AND ITS PROPERTIES.

AT a recent meeting of the Institution of Civil Engineers, two papers were read on manganese steel, viz.: (1) "Manganese in its Application to Metallurgy" and (2) "Some Novel Properties of Iron and Manganese," both by Mr. Robert Abbott Hadfield, Assoc. M. Inst. C. E.

The first paper commenced with a statement that Hadfield's Steel Foundry Company, Sheffield, was, some time ago, in search of a material suitable for making castings which should possess hardness and toughness, as ordinary steel castings did not combine these qualities. Cast steel, unlike cast iron, could not be "chilled." This was a great disadvantage, for although steel castings of ordinary temper might be exceedingly tough, as soon as hardness was reached, by an addition of carbon or other elements, the toughness rapidly decreased, the material became brittle, and did not possess the intense hardness of chilled iron. Even cast steel with more than 2 per cent. of carbon was comparatively soft, and while chilled iron cylinders, 0·79 in. in diam. by 1 in. long, remained unaltered under a load of 100 tons per square inch, cast or forged steel cylinders, if unhardened, shortened from 15 to 40 per cent., according to temper. If molten steel of any temper, as hitherto made, was run into an iron mould used for making "chilled rolls," when cold the grain of the casting would be somewhat closer than if cast in sand, but still quite soft, easily indented, and the metal might be turned in ordinary lathes. The same article made from cast iron of suitable mixtures would be intensely hard on the surface. Here, then, was a drawback to cast steel, as, although it might be hardened when immersed in water or oil, this application was impracticable to the many irregular forms dealt with by steel founders; besides, the intense strains brought to bear by such hardening process would cause the articles to crack and break into pieces. It had, therefore, been thought that an account of the results noticed in connection with the material termed "manganese steel" might prove of interest to the Institution of Civil Engineers, particularly as it offered advantages over ordinary steel in some points. Moreover, it seemed to afford new fields for investigation in metallurgy, since many of the results noted in its production were contrary to general experience. Laws hitherto accepted and considered to be well defined were apparently set on one side, and it was possible, therefore, by the facts being discussed, to throw light upon the subject. The field for investigation and extension in the knowledge of the alloys of iron was very wide, but as yet comparatively little had been done. The knowledge of steel had so far been principally confined to carbon steel or alloys of iron and carbon, about nine-tenths of the steel made being of this class.

The first paper principally dealt with and described the experiments, the physical properties noticed in the material and the conclusions to be drawn therefrom being more particularly defined in the following one. Special attention was drawn to what essentially constituted the peculiarity of manganese steel. While the belief hitherto held, that steel became brittle and comparatively worthless when the manganese exceeded 2·75 per cent., was correct, it had now been proved that by adding more of the same metal, so as to obtain in the material under treatment not less than about 7 per cent. manganese, the result was a new metal. The apparent paradox thus took place that while manganese alloyed with iron, if present in the proportion of not less than 2·75 and up to about 7 per cent., gave a very brittle product, when its proportion was increased to not less than 7 and up to about 20 per cent., the result was a material possessing peculiar and extraordinary strength and toughness. The brittleness of the cast material seemed to partake more of the nature of glass, or other similar substance, than of a metal such as steel.

Cast bars, about $2\frac{5}{8}$ in. square in cross section, 30 in. long, were supported upon bearings 2 ft. apart, and broken under hydraulic pressure, the breaking load being carefully noticed in each case. One of these specimens, containing 0·37 per cent. carbon and 4·45 per cent. manganese, was fractured under a pressure of $3\frac{3}{4}$ tons, while a bar of ordinary cast iron stood 12 tons, and the higher percentages of manganese, 17 and 20 per cent. respectively, stood $29\frac{1}{2}$ and 38 tons. Another instance was afforded by a bar casting, containing 4·73 per cent. manganese, being dropped from a height of 3 ft. to 4 ft. on a floor paved with cast iron, when fracture occurred in two or three parts of the bar at the same time, showing its extraordinary fragility.

Pieces from another specimen, containing 0·48 per cent. carbon and 4·9 per cent. manganese, though exceedingly ductile when hot, in the cast state when cold could be reduced by a hand hammer to fine powder, no cohesion seeming to exist between the particles. On the other hand, a specimen of forged material, containing 13·75 per cent. manganese and 0·85 per cent. carbon, when water-toughened, had a tensile strength of 65 tons per square inch, with 50·7 per cent. elongation, and another specimen 69 tons and 46 per cent. respectively. In the latter case, the tensile load, calculated on the area of the bar at the moment of fracture, was equal to 102 tons per square inch. The combination of hardness and toughness found in this material led to experiments as to whether edge tools could be cast from it. These tools, while not equal to those made of forged, hardened, and tempered steel, had afforded some remarkable results.

The author exhibited some castings as they left the moulds, the cutting edges merely being ground up, and neither hardened nor tempered. These included a cast ax, which had chopped through cold iron, along with the pieces of iron cut through. Another ax of the same quality, which had been used for over two years, readily shaved off the hair on the back of the hand, and cast razors had been made which, while not equal to those of ordinary steel, had done fairly well. A cast adz and chisel for wood were also shown, both of which had been constantly in use for over two years, and had cut through the hardest knots and hard wood. Manganese steel possessed toughness to resist severe usage, and hardness to prevent permanent set without bending or buckling. Some of the tests showed that the material had these qualities in a most remarkable degree. The tests were made with an ordinary drop tup, sliding between steel rails fastened to strong timber supports, which was allowed to fall on Browning's coupler castings. The tup weighed 2,324 lb., and the drop could be varied from 1 ft. to 27 ft. Each casting was placed vertically, and the tup allowed to fall upon the jaws, the permanent set being carefully measured after each blow. Exact particulars of the remarkable results obtained from the manganese steel were given. The couplers tested were an American malleable iron casting, a manganese steel casting, containing 9·37 per cent. manganese, tested just as cast, a tough mild steel casting, containing 0·25 per cent. carbon, having a breaking strength of 32 tons per square inch, with an elongation of 30 per cent. on 2 in., also two manganese steel castings, water-toughened, containing respectively 9·75 and 14·25 per cent. manganese, which were unbroken, notwithstanding that the latter had more than 300 foot tons of energy expended upon it. The author directed attention to the peculiar hardness of this steel, both in its cast and in its forged condition. The specimens were so exceedingly hard that it was scarcely possible to machine any of them on a practical scale. The hardness was most intense in the cast material containing 5 to 6 per cent. manganese, which no tool would face or touch. A gradual decrease then occurred, and when about 10 per cent. was reached, the softest condition was attained. Then an increase again took place, and at 22 per cent. it was very hard, still not so much so as in the 5 per cent. specimens. After passing 22 per cent. the cause of hardness became more complicated, owing to the presence of more carbon, 2 per cent. and upward; in fact, the material began to partake more of the nature of cast iron, but it had greater transverse strength. A test bar, with 14 per cent. manganese, which elongated 44·5 per cent. without fracture, and had a tensile strength of 67 tons, was put under a double geared 18 in. drill. Over an hour was occupied in drilling one hole $\frac{1}{8}$ in. in diameter by $\frac{3}{8}$ in. deep, during which time fifteen to twenty holes of the same size could have been easily drilled in mild steel. Similar results from specimens sent to different engineering firms confirmed the above, yet this specimen could be indented by an ordinary hand hammer. Although, when being turned, it appeared harder than chilled iron, its softness was particularly noticeable when testing the material for compression. Specimens of 10 per cent. manganese steel, 1 in. long by 0·79 in. in diameter, notwithstanding they required several days' preparation in the lathe owing to their hardness, yet under a compression load of 100 tons per square inch shortened 0·25 in., and the harder kind 0·1 in. to 0·13 in. Chilled iron or hardened steel would stand this test without any alteration. Attention was also directed to the fact that a load of 27 tons per square inch, which in ordinary mild steel would cause fracture, and an elongation of 30 per cent. on 8 in., only elongated manganese steel 0·53 per cent. on the same length. A hammered manganese steel bar was compared with a best quality steel railway axle of the same diameter as the manganese steel bar. The results of the tests showed that on the manganese steel bar or axle an energy of 498 foot tons produced total deflections of only $89\frac{1}{2}$ in., whereas on the special steel axle an energy of 348 foot tons produced total deflections of $105\frac{1}{4}$ in. Assuming the manganese steel to have been capable of resistance without fracture, and the deflections to have continued in the same proportion, an energy of no less than 1,360 foot tons would have been required to effect the same deflections that 348 foot tons produced on the special or carbon steel axle. The peculiarly combined toughness, hardness, and stiffness of manganese steel, either cast or forged, were very clearly brought out in these tests. The material, therefore, seemed well adapted to resist severe stress before fracture, and yet at the same time to show very slight alteration under stress. The author stated that the results having been often anomalous as compared with ordinary steel, special care had been taken to thoroughly verify each experiment. If contradiction sometimes occurred, it might be partly explained by the want of knowledge requisite in dealing with a new material. In conclusion, the author referred to the inadequacy of the explanations offered with reference to some of the peculiarities noticed in manganese steel. His remarks were, therefore, in many instances, offered only in the nature of suggestions for the consideration of scientific and metallurgical authorities. The field for investigation was very wide, and his object had been to describe the experiments made with care and exactitude.

In the second paper considerations were offered as to the causes of the results noticed in the previous one; but before proceeding to these the author remarked that some decision ought to be arrived at upon the exact meaning of the word "steel." Numerous combinations or alloys were being manufactured to which this term was given. It had hitherto been applied to malleable alloys or mixtures of iron and carbon, and the author pointed out some peculiar features in alloys or compounds of iron and manganese which also possessed a steel-like nature. In some correspondence with the author, Mr. R. Mushet wrote: "Your material is really not steel, but an alloy in certain proportions of iron and metallic manganese containing also carbon, but as little of that as you can help. Your alloy possesses some of the properties of steel, and it is to a certain extent a substitute for steel, just as brass, which is not copper, is nevertheless a substitute for copper." While there was much to be said for this view, it was open to consideration whether iron formed actual compounds or mere mixtures or alloys. Steel had been defined by Bresson as "a particular state of iron produced by its union with bodies the nature of which can vary. There are three classes: first, steels composed of iron and carbon; second, those of iron, carbon, and a third body; third, those formed of iron and another body which is not carbon." It would be seen from the properties of manganese steel that this view was correct, and that bodies other than carbon could play a constituent part in the conversion of iron into steel; in fact, Faraday, long ago, was reported to have made an alloy of iridium and iron which possessed steel-like properties, although no carbon was present. When plunged in water, the behavior of manganese steel was quite different to that of ordinary carbon steel, no hardening action taking place. Water certainly caused the material to become stiffer, but in a different degree to hardened carbon steel; for a piece of manganese steel after such treatment was slightly more easily touched by a file; therefore the process was termed water toughening. The increase in stiffness was marked, the tensile strength rising from 40 to 60 and in some cases over 70 tons per square inch; but this was not a mere stiffening or hardening effect in the ordinary sense of the term, for in carbon steel such rise was invariably accompanied, when the cooling medium was water, by a considerable decrease in the ductility or elongation, whereas, in manganese steel, just the opposite effect was produced. When, however, the samples contained below about 7 per cent. manganese, this treatment seemed to exercise little or no influence, and the material was comparatively valueless where toughness was requisite. After a large number of tests on the action of heat and sudden cooling upon this material, it had been found, generally speaking, that the higher the heat of the piece treated, and the more sudden and rapid the cooling, the higher would be its breaking load and the greater its toughness or elongation. This was very apparent from the results of six bars which were heated as uniformly as possible to a yellow heat, and plunged into water of 72° F., which gave breaking loads varying from 57 to 63 tons per square inch, and elongations of 30·8 per cent. to 50 per cent. For comparison another test bar of the same material was heated in precisely the same way and degree, but plunged into water at a temperature of 202° F., when the results were only 53 tons and 32·8 per cent. The more rapid cooling of the other test bars was evidently the cause of their superiority, the chemical composition of all being the same. It was also thought that sulphuric acid, being a rapid conductor of heat, might give good results as a cooling medium. The experiment was therefore made with a bath consisting of equal volumes of water and sulphuric acid, and on 8 in. the extraordinary elongation of 50·7 per cent. was reached with a breaking load

of 65 tons, the bar being thus drawn cold $4\frac{1}{16}$ in. before fracture. Another specimen on 4 in. length gave 56·75 per cent. Various experiments were made to show the influence of manganese upon forged iron, the former varying from 0·86 to 21·69 per cent. under different modes of treatment. It was found that oil had a beneficial effect on the metal, but not equal to either water or sulphuric acid; this no doubt was due to its lower conductivity. It was also noticed that the operation of merely heating the forged test bar to a yellow heat and cooling it in air had a very beneficial effect, the elongation in most instances being increased to 15 and 20 per cent., the tensile strength also rising 8 or 10 tons per square inch. It was not easy to understand the action of the water quenching process. As explained by Chernoff, the effect of oil tempering on ordinary steel was to produce a metal of fine grain, which possessed much greater strength than open, coarse grained steel. If, however, forged manganese steel possessed any difference of structure after being heated and water-toughened, it was rather in the direction of a more open than a closer grain. But the most puzzling case in the author's experience was that of cast toughened specimens containing 9 per cent. manganese, at which percentage the crystallization was very peculiar. An ingot 2½ inches square in cross section and 2 ft. long was cast in an iron mould. When cold, a piece was broken off under four blows of a steam hammer. The fracture showed the usual peculiar form of the 9 per cent. material, a form which to outward appearance was unchanged by any heat short of the melting point. The other piece was reheated to a yellow heat and water-quenched. In this the toughness was increased in a remarkable manner, ten blows of the steam hammer being required to break the bar, although the appearance of fracture was unchanged. This material possessed the peculiar property of being almost entirely non-magnetic, which was curious, seeing that iron was present in amounts eight or nine times greater than the manganese. An approximate idea of the amount of manganese contained in steel might be formed by passing a magnet over specimens; as the percentage of manganese increased, the effect of the magnet diminished. Upon reaching about 8 per cent. there was no attraction in the bulk, though fine drillings were influenced; but when 20 per cent. was reached, a magnet capable of lifting 30 lb. of ordinary steel or iron would only lift pieces weighing a few milligrammes. No advantage was gained in ordinary steel by adding more than 1·5 to 1·75 per cent. of carbon, an amount above this not producing steel with any greater degree of hardness. Hence, the analysis of the majority of Sheffield carbon tool steels showed not more than 1¼ to 1½ per cent carbon; at these tempers the point of saturation, so to speak, seemed to have been reached, so that carbon itself could hardly be the sole cause of hardness. The question, therefore, of the crystallization or structure became of great importance. No one could well mistake the difference of fracture in wrought iron and in mild steel, though both might give by analysis the same percentage of iron; in fact, wrought iron might even contain more carbon than mild steel, and yet the structure in no way resemble that of the latter. It was apparent, therefore, that iron did vary its form or structure. This was noticed by steel casting manufacturers, who by judicious treatment could increase the elongation of steel as cast from 8 or 10 per cent. up to 30 per cent. Professor Barrett had noticed another point of difference between this and carbon steel. Manganese steel, when cooling, did not give any "after-glow." A Sheffield firm also reported that in rolling a length of 800 ft. in one piece of this wire, the finer it became the more it seemed to retain the heat—in fact, it appeared to gather heat in the process. In conclusion, the author again contended that some understanding should be arrived at as to the meaning of the term "steel." In the past this word had sufficed well enough for an alloy or compound of iron and carbon; but the latter was in many instances now being replaced by other elements, such as manganese, chromium, silicon, or tungsten. The author held that steel was but a particular state of iron produced by the union of that metal with bodies the nature of which might vary.

The papers were illustrated by an extensive collection of samples of manganese steel, and of ordinary steels, which will remain on view at the Institution for a few days. The discussion on these papers was resumed recently.

PRACTICAL HINTS ON WATER COLOR PORTRAIT PAINTING OVER PHOTOGRAPHIC ENLARGEMENTS.

By E. W. CURRIER.

HAVING secured a solar print (egg shell paper), the first work is to touch out all white spots or imperfections in the face, which is done with a pigment composed of India ink, Indian red, and natural tint mixed together on the palette to match the tone of your print.

This done, the flesh wash is flowed over the face. This wash is composed of scarlet vermilion with a large quantity of water, mixed in a water color slant. Use a No. 10 red sable brush and work across the face, beginning at the top of forehead and working the color down evenly.

Having now applied this tint evenly over the entire face, let it get thoroughly dry before working in the shadows.

Directions for Painting the Hair.—For brown hair, use sepia toned down with lamp black, if dark brown; if of a reddish brown or auburn cast, add a little burnt sienna to your sepia. For black hair, use lamp black with ivory black for the strong shadows. Blonde hair may be made with Roman ocher, or yellow ocher with Chinese white, according to the tint. Always use great care in painting the hair. Avoid getting a wiry or ropy appearance. Always soften the edges of hair with a wet brush, especially next the forehead. For the darkest shadows over the eyes, the nostrils, and shadow between the lips, use brown madder, with the edges softened with Rubens madder. Rose madder is used for painting the under lip, and cobalt blue should be stippled in around the edges of the lips, also in the half tints between hair and forehead and around eyebrows.

Rose madder should be hatched in the center of cheeks in a delicate tint.

In painting the eyes be careful not to have the catch light too large, as this light seems to enlarge out of proportion by photography; also preserve the shape and location of this catch light, as this gives the expression to the eyes. For blue eyes use Payne's gray; for brown eyes, sepia; for black eyes, ivory black with a touch of sepia; for hazel eyes, use Payne's gray on the outside of the iris, and burnt sienna next to the pupil. For the whites of eyes use Chinese white lowered with cobalt and a slight touch of lamp black, painting in a touch of pale vermilion in the corners of eyes nearest the nose.

Directions for Working the Drapery.—For black drapery use lamp black, having first darkened the shadows with No. 3 Conte crayon with your chamois stump. Pulverized pumice stone mixed with powdered No. 3 black Conte crayon make a very valuable prepation for working drapery of all kinds, also for shading the background. For dark backgrounds where a dark stippled ground is desired, use sepia mixed in a thin wash with Prussian blue. After working the drapery the face may again occupy our attention. The first wash we applied being now perfectly dry, stipple in the shadows with a tint composed of sepia and indigo blue with *brown madder* worked into the deeper shadows. Do not get your eyes too near your work while stippling, but sit with your arm at full length, as the uneven surface is much easier smoothed up when not too close to the picture. For navy blue suits or soldiers' coats, use Prussian blue mixed with water of ammonia, as the ammonia makes the wash flow smoothly, for if not used it is almost impossible to put on the wash evenly, as Prussian blue is a poor color to use in washes. In painting white lace collars, trimming, etc., use Chinese white and neutral tint for first painting, and when dry paint in the pattern of the lace with pure Chinese white. Use a little cobalt blue in thin washes in the shadows of the lace. For jewelry use gold bronze for first painting, and when dry shadows are painted in with sepia, and the high lights with Chinese white and a slight tint of Naples yellow added to the white. The following list of colors are necessary:

Reynolds' Chinese white,	Roman ocher,
Ivory black,	Yellow "
Lamp "	Naples yellow,
Prussian blue,	Burnt sienna,
Indigo "	Burnt umber,
French "	Raw "
Cobalt "	Bister,
Payne's gray,	Sepia,
Scarlet lake,	Neutral tint,
Scarlet vermilion,	Emerald green,
Rose madder,	Indian yellow,
Brown "	Carmine,
Rubens "	Hooker's green,
Indian red,	Vandyke brown.
Italian pink,	

A stick of No. 3 black Conte crayon, a chamois skin stump, 1 oz. pulverized pumice stone, 1 slant tumbler, and the following numbers of long handled red sable brushes, Nos. 4, 5, 6, 7, 10, and 12, and a large black sable brush for washes. I prefer one with a brush at each end. These materials are to be found at any artists' material store. To give relief to a head or figure, the background should be darkest back of the light side of head or figure, and lighter next to the shadowed side of the head. Be careful in stippling the face not to use the color very thick in the brush or very much color in your brush. Soften all the edges of the drapery and features, leaving no sharp lines. Rubens, the great artist, is reported to have said, "Paint your lights white, place next to that yellow, then red, using dark red as it passes into the shadow. Then, with a brush dipped in cool gray, pass gently over the whole till they are tempered and sweetened to the tone you wish." His remarks apply to painting in oil, but the principle is the same in water colors. Drawing is of infinite importance to the student of art, and we would suggest all spare time be occupied in drawing from Ducollet, "Elementary Studies of Features and Heads," which can be obtained of Janentzky & Weber, 1125 Chestnut Street, Philadelphia, also Julien, "Etudes d'apres l'antique," collection of the best antique studies from European museums, to be had at the same store. These should be copied with charcoal, using charcoal paper, and stale bread for removing too heavy shadows or when mistakes are made in the drawing. The drawings may be *fixed* after being finished by blowing the surface over with fixative, by means of the atomizer, kept at all artists' material stores. Observe, when painting eyes in a portrait, to paint in the catch light on the same side of the eye as the light falls on the face. We have often seen this mistake made among amateurs—the catch light painted in on the shadowed side of a face, which is entirely wrong.

As it is often convenient to understand something about landscape painting, as used in backgrounds of figure paintings, a few words in regard to the same would not be out of place. For skies, use cobalt blue and a little lamp black added. After this wash is dry, the distance may be washed over with a thin solution of rose madder. For tree trunks, Vandyke brown or Payne's gray may be used. For the leaves, a green composed of Indian yellow and lamp black and burnt sienna. Never have the foliage a decided green, but use burnt umber with the greens, which softens the tone. In autumn scenes a wash of light red may be flowed entirely over the ground and sky. After getting dry it can be painted over in the usual manner. This wash tends to give a warm tone not to be obtained by any other method. The shadows of a color always partake of their complementary color. This rule applies to all paintings where color is used. But the complementary color must not be used strong, only a very slight tint. For instance, green is the complementary color to red. Hence a piece of red drapery has a greenish tint in the shadows. Orange is the complementary color to blue, yellow is the complementary color to violet, and so through all the list of shades and tones. The primary colors are red, blue, and yellow. A great variety of colors can be made by mixing these colors in different combinations, as follows: If Prussian blue be mixed with Indian yellow, a brilliant green is the result. Carmine mixed with Prussian blue produces a beautiful violet. Vermilion mixed with gamboge yellow gives a bright orange. Lamp black mixed with yellow gives a dull green. Burnt sienna mixed with yellow gives a dull orange. By experimenting a little in the mixing of other shades, different tones of color can easily be made. Always remember to soften the edges of objects in painting them. This can be best done with a brush containing only water being passed over the edges of hair or drapery so as to leave the lines soft and not sharp.

ENGLISH CHINA, OR TENDER PORCELAIN.*

THE Chinese as a nation long possessed the secret of manufacturing a species of pottery differing from all other kinds in being semi-transparent. The secret of its production, however, was not discovered by Europeans until the beginning of the eighteenth century, when Böttcher, of Meissen, made the first European porcelain, and founded the manufacture of Dresden china. But England was not far behind in the solution of the problem, and a few decades later we find the manufacture of translucent pottery an established industry at Bow, whence the process was removed to Derby, ever since then renowned as a seat of china making. The methods discovered and adopted by the two nations are, perhaps, good examples of their characteristic qualities. By the employment of laborious research and unflagging application, Böttcher after innumerable trials imitated the Chinese, and made an article in every respect similar to theirs. The English potters, however, proceeded by original methods, and arrived by one happy stroke of genius at a material having the same translucency as true Oriental porcelain, while at the same time possessed of properties that have enabled our native potters to lavish upon it great beauty of finish and wealth of ornament. The single discovery whereby vessels of porcelain were made almost at a bound accessible to the poorest classes was the employment of bone ash, which, when added in due proportion to kaolin and ground china stone, imparts, under the influence of fire, the semi-transparency characteristic of porcelain ware. The effect thus gained, independently of chemistry, by the use of bone earth, has ever since remained to a great extent unexplained, or, at any rate, little understood by the writers of the few works on pottery manufactures, and we find it stated that the "phosphoric acid of the bone ash diffuses itself at a high temperature through all the materials, uniting them into a translucent enamel, which, being less apt to shrink and lose its form than the hard china body, may be baked in larger kilns, and with less risk of loss to the manufacturer;" and again, it is stated that "English china is rendered translucent by the addition to a pure plastic clay of a considerable proportion of glass-forming materials, but the proportion is so regulated that, although the ware does not require excessive heat for its firing, its plasticity is sufficient to facilitate manipulation; moreover, the balance of fusibility and plasticity is so adjusted as to allow the introduction of sufficient calcic phosphate to reduce the shrinkage of the ware to a minimum, and at the same time greatly to add to its brilliancy.... The translucency of English china is due to the fusion of the feldspar contained in the Cornish stone. The calcic phosphate performs many useful functions. In addition to reducing shrinkage, and enhancing the whiteness of the ware, it enables it by its infusibility to stand the fire requisite for the vitrification of the feldspar, and adds lightness without materially affecting transparency." Here then we find calcic phosphate and bone ash used almost, if not quite, as synonymous terms; in the first case the phosphate is said to "diffuse itself," forming an "enamel" with the other ingredients; in the second it is said to impart infusibility, lessened shrinkage, and greater lightness to the ware, and the translucency is attributed to the feldspar. The writers appear to have overlooked the double part which bone ash plays in the fabrication of porcelain. Very simple experiments will show that bone ash and phosphate of calcium (lime) are two very different materials when regarded from the potter's standpoint. Experiments made in a biscuit oven by the author, with the kind permission of Mr. John Hudson (Messrs. W. Hudson & Co.), of Longton, throw considerable light upon the function of bone ash in china making. A number of mixtures were submitted to the oven during ordinary firings: (1) Bone ash, 7 parts; china stone, 4½ parts; kaolin, 4 parts. This, which represents the usual china mass, was mixed with water and moulded into a small article, and after drying it was fired. The result was a good translucent specimen of china. (2) In another experiment the following ingredients were used: 7 parts of pure calcium phosphate, with kaolin and china stone as before. The outcome was now a sample of white stone ware, quite devoid of transparency, which result effectually demolishes the theory of diffusibility and enamel formation on the part of the phosphate. (3) In this instance 5 parts of calcium phosphate were employed, with the addition of 2 parts of calcium carbonate (equal to 1·1 parts of calcium oxide or lime), and the same proportions of clay and stone as before. The product was true semi-transparent china, equal in all respects to ordinary china, as far as could be judged from the small specimen. Trial No. 2 therefore seems to show clearly that china does not owe its transparency to any preponderating extent to the china stone, although of course the stone must have some effect in this direction. Experiment No. 3, on the other hand, establishes the great effect exerted by the lime in bone ash in producing translucency.

The function of calcium phosphate still required elucidation, and much light was thrown upon the subject by similar trials in the biscuit kiln, using phosphate of aluminum instead of phosphate of calcium. Pure phosphate of aluminum, prepared without the use of alkaline salts, behaves exactly like pure calcium phosphate in the blowpipe flame and biscuit oven, being apparently quite unaffected. Either of these substances made by precipitation with sodium phosphate fuses readily, even after considerable washing, the liquefaction being produced by small traces of alkali obstinately retained by the precipitate. The fusibility of bone ash cannot be so explained, and is doubtless due to the silica. This constituent is not present in the original bones, but is derived from the mill stones and other sources; it is frequently present to the extent of 5 per cent., or even more, in potter's bone ash, with which the experiments were made. Using pure phosphate of alumina 7 parts, clay and

* Abstract of paper read by Thomas Bayley, before the Birmingham Section of the Society of Chemical Industry, on March 7.

stone as before, there was obtained neither porcelain nor stone ware, but a semi-fused and distorted object, translucent in an inferior degree, and very far from possessing the necessary rigidity in the fire. When 5 parts of phosphate of aluminum and 2 parts of calcium carbonate (equal to 1·1 parts lime) were substituted for the 7 parts of aluminum phosphate, the result was the same, but the translucency was a little greater, and the fusibility still more apparent. Evidently, then, aluminum phosphate cannot be employed in place of calcium phosphate, and the effect of the latter upon china must be due to other properties than its infusibility and non-liability to shrinkage, although these may be of advantage. The key to the mystery is readily found. Every experienced analyst knows how difficult it is to make a separation of phosphoric acid from calcium by dry reactions, even by fusion with such powerful agents as alkaline carbonates, and how comparatively easy it is to decompose aluminum phosphate by fluxing with alkalies in presence of silica. Hence we may conclude that in the indecomposable nature of calcium phosphate, under circumstances analogous to those of the alkaline separation, lies the potency of phosphate of calcium for the operations of the potter. In other words, this phosphate remains unattached and isolated, and, being infusible at the heat of the oven, affords a support to the glassy substances formed by the mutual action of the alkali of the china stone, the lime of the bone ash, and the silica and alumina of the remaining ingredients. The calcium phosphate, therefore, acts as a backbone, and enables the English potter to employ a high percentage of vitrifying ingredients, and thus obtain the required translucency at a lower temperature than is possible in the manufacture of true china by the Oriental and German methods, and with less distortion and loss in firing. It appeared possible that if aluminum phosphate were mixed with its equivalent of calcium carbonate, together with clay and stone, the result might be formation of calcium phosphate and alumina, in which case a refractory china would be produced. Experiments, however, proved that this is not the case; the trials emerged from the biscuit oven semi-fritted and opaque. The capacity of calcium phosphate, therefore, does not appear to lie so much in its stability of formation at great heats, so to speak, as in its inertness when present from the beginning. With regard to its effect upon transparency, the author suggested that the relations between the indices of refraction of the calcium phosphate and of the glassy materials might not be without influence.—*Industries.*

[NATURE.]

TIMBER, AND SOME OF ITS DISEASES.*

By H. MARSHALL WARD.

III.

HAVING now obtained some idea of the principal points in the structure and varieties of normal healthy timber, we may pass to the consideration of some of the diseases which affect it. The subject seems to fall very naturally into two convenient divisions, if we agree to treat of (1) those diseases which make their appearance in the living trees, and (2) those which are only found to affect dead timber after it is felled and sawn up. In reality, however, this mode of dividing the subject is purely arbitrary, and the two categories of diseases are linked together by all possible gradations.

Confining our attention for the present to the diseases of standing timber—*i. e.*, which affect undoubtedly living trees—it can soon be shown that they are very numerous and varied in kind; hence it will be necessary to make some choice of what can best be described in this article. I shall therefore propose for the present to leave out of account those diseases which do injury to timber indirectly, such as leaf diseases, the diseases of buds, growing roots, and so forth, as well as those which do harm in anticipation by injuring or destroying seedlings and young plants. The present article will thus be devoted to some of the diseases which attack the timber in the trees which are still standing; and as those caused by fungus parasites are the most interesting, we will for the present confine our attention to them.

It has long been known to planters and foresters that trees become rotten at the core, and even hollow, at all ages and in all kinds of situations, and that in many cases the first obvious signs that anything is the matter with the timber make their appearance when, after a high gale, a large limb snaps off, and the wood is found to be decayed internally. Now it is by no means implied that this rotting at the core—"wet rot," "red rot," etc., are other names generally applied to what is really a class of diseases—is *always* referable to a single cause; but it is certain that in a large number of cases it is due to the ravages of fungus parasites. The chief reason for popular misconceptions regarding these points is want of accurate knowledge of the structure and functions of wood on the one hand, and of the nature and biology of fungi on the other. The words disease, parasitism, decomposition, etc., convey very little meaning unless the student has had opportunities of obtaining some such knowledge of the biology of plants as can only be got in a modern laboratory; under this disadvantage the reader may not always grasp the full significance of what follows, but it will be at least clear that such fungi demand attention as serious enemies of our timber.

It will be advantageous to join the remarks I have to make to a part description of some of the contents of what is perhaps one of the most instructive and remarkable museums in the world—the Museum of Forest Botany, in Munich, which I have lately had the good fortune to examine under the guidance of Prof. Robert Hartig, the distinguished botanist to whose energy the museum is due, and to whose brilliant investigations we owe nearly all that has been discovered of the diseases of trees caused by the Hymenomycetes. Not only is Prof. Hartig's collection unique in itself, but the objects are classical, and illustrate facts which are as yet hardly known outside the small circle of specialists who have devoted themselves to such studies as are here referred to.

One of the most disastrous of the fungi which attack living trees is *Trametes radiciperda* (Hartig), the *Polyporus annosus* of Fries, and it is especially destructive to the coniferæ. Almost every one is familiar with some of our common polyporei, especially those the fructifications of which project like irregular brackets of various colors from dead stumps, or from the stems of moribund trees; well, such forms will be found on examination to have numerous minute pores on the under side or on the upper side of their cheese-like, corky, or woody substance, and the spores which reproduce the fungus are developed on the walls lining these

FIG. 11.—Portion of root of a spruce fir, with fructification of *Trametes radiciperda* (after Hartig). Each fructification is a yellowish white mass of felt-like substance spread over the root, and with minute pores, in which the spores are produced, on its outer surface: the mycelium which has developed it is in the interior of the root.

many pores to which these fungi owe their name. *Trametes radiciperda* is one of those forms which has its pores on the upper side of the spore-bearing fructification, and presents the remarkable peculiarity of developing the latter on the exterior of roots beneath the surface of the soil (Fig. 11).

This is not the place to discuss the characters of species and genera, nor to enter at any detail into the structure of fungi, but it is necessary to point out that in those cases where the casual observer sees only the fructification of a polyporus, or a toadstool, or of a mushroom (projecting from a rotting stump or from the ground, for instance), the botanist knows that this fructification is attached to, and has taken origin from, a number of fine colorless filaments woven into a felt-like mass known as the mycelium, and that this felt work of mycelium is spreading on and in the rotten wood, or soil, or whatever else the fungus grows on, and acts as roots, etc., for the benefit of the fructification.

Now, the peculiarity of the mycelium of this *Trametes radiciperda* is that it spreads in the wood of the roots and trunks of pines and firs and other conifers, and takes its nourishment from the wood substance, etc., and it is to the researches of Hartig that we owe our knowledge of how it gets there and what it does when there. He found that the spores germinate

FIG. 12.—Piece of root of spruce fir, with the mycelium of *Trametes radiciperda* (after Hartig), enlarged about three times. The white mycelium spreads in a fan-like manner over the surface beneath the cortex, as seen in the figure where the latter has been lifted and removed (*a*). Here and there the mycelium bursts through the cortex in the form of white protuberances (*b*), to form the fructifications.

easily in the moisture around the roots, and put forth filaments which enter between the bark scales, and thus the mycelium establishes itself in the living tree, between the cortex and the wood (Fig. 12). It is curious to note that the spores may be carried from place to place by mice and other burrowing animals, since this Trametes is apt to develop its fructification and spores in the burrows, and they are rubbed off into the fur of the animals as they pass over and under the spore-bearing mass.

When the mycelium obtains a hold in the root, it soon spreads between the cortex and the wood, feeding upon, and of course destroying, the cambium. Here it spreads in the form of thin flattened bands, with a silky luster, making its way up the root to the base of the stem, whence it goes on spreading further up into the trunk (Fig. 12).

Even if the mycelium confined its ravages to the cambial region, it is obvious, from what was described in Articles I. and II., that it would be disastrous to the tree; but its destructive influence extends much further than this. In the first place, it can spread to another root belonging to another tree, if the latter comes in contact in the moist soil with a root already infected; in the second place, the mycelium sends fine filaments in all directions into the wood itself, and the destructive action of these filaments—called hyphæ—soon reduces the timber, for several yards up the trunk, to a rotting, useless mass. After thus destroying the roots and lower parts of the tree, the mycelium may

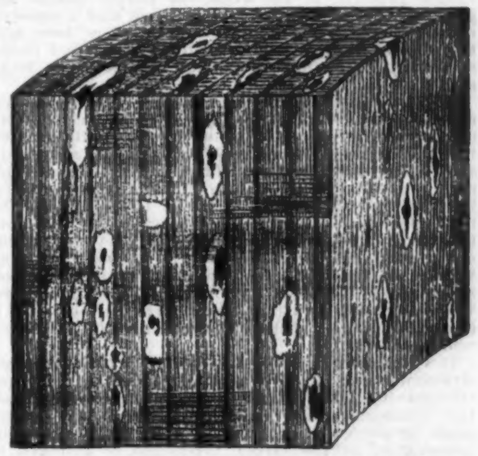


FIG. 13.—A block of the timber of a spruce fir, attacked by *Trametes radiciperda*. The general color is yellow, and in the yellow matrix of less rotten wood are soft white patches, each with a black speck in it. These patches are portions completely disorganized by the action of the mycelium, and the appearance is very characteristic of this particular disease. (After Hartig.)

then begin to break through the dead bark, and again form the fructifications referred to.

Since, as we shall see, *Trametes radiciperda* is not the only fungus which brings about the destruction of standing timber from the roots upward, it may be well to see what characters enable us to distinguish the disease thus induced in the absence of the fructification.

The most obvious external symptoms of the disease in a plantation, etc., are: The leaves turn pale, and then yellow, and die off; then the lower part of the stem begins to die, and rots, though the bark higher up may preserve its normal appearance. If the bark is removed from one of the diseased roots or stems, there may be seen the flat, silky, white bands of mycelium running in the plane of the cambium, and here and there protruding tiny white cushions between the scales of the bark (Fig. 12); in advanced stages the fructifications developed from these cushions may also be found. The wood inside the diseased root will be soft and damp, and in a more or less advanced stage of decomposition.

On examining the timber itself, we again obtain distinctive characters which enable the expert to detect the disease at a glance. I had the good fortune to spend several pleasant hours in the Munich Museum examining and comparing the various diseases of tim-

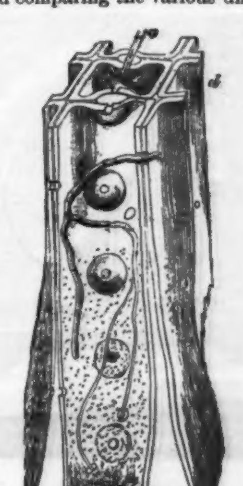


FIG. 14.—Sectional view of a tracheide of the spruce fir, attacked by the hyphæ (*a*, *b*) of a *Trametes*, highly magnified (after Hartig). The upper part of the tracheide has its walls still sound, though already pierced by the hyphæ; the lower part (*c*) has the walls completely delignified, and converted into cellulose, which swells up and dissolves. The middle lamella is also undergoing dissolution. The holes in the walls have been bored by hyphæ.

bers, and it is astonishing how well marked the symptoms are. In the present case the wood at a certain stage presents the appearance represented in the drawing, Fig. 13. The general tone is yellow, passing into a browner hue. Scattered here and there in this groundwork of still sounder wood are peculiar oval or irregular patches of snowy white, and in the center of

*Continued from SUPPLEMENT, No. 638, page 10190.

each white patch is a black speck. Nothing surprised me more than the accuracy with which Prof. Hartig's figures reproduce the characteristic appearance of the original specimens in his classical collection, and I have tried to copy this in the woodcut, but of course the want of color makes itself evident.

It is interesting and important to trace the earlier changes in the diseased timber. When the filaments of the fungus first begin to enter the wood, they grow upward more rapidly than across the grain, piercing the walls of the cells and tracheides by means of a secretion—a soluble ferment—which they exude. This ferment softens and dissolves the substance of the walls, and therefore, of course, destroys the structure and firmness, etc., of the timber. Supposing the filaments to enter cells which still contain protoplasm and starch, and other nutritive substances (such as occur in the medullary rays, for example), the filaments kill the living contents and feed on them. The result is that what remains unconsumed acquires a darker color, and this makes itself visible in the mass to the unaided eye as a rosy or purple hue, gradually spreading through the attacked timber. As the destructive action of the fungus proceeds in the wood, the purple shades are gradually replaced by a yellowish cast, and a series of minute black dots make their appearance here and there; then the black dots gradually surround themselves with the white areas, and we have the stage shown in Fig. 13.

These white areas are the remains of the elements of the wood which have already been completely delignified by the action of the ferment secreted by the fungus filaments—*i. e.*, the hard woody cell walls have become converted into soft and swelling cellulose, and the filaments are dissolving and feeding upon the latter (Fig. 14). In the next stage of the advancing destruction of the timber the black dots mostly disappear, and the white areas get larger; then the middle lamella between the contiguous elements of the wood becomes dissolved, and soft places and cavities are produced, causing the previously firm timber to become spongy and soft, and it eventually breaks up into a rotting mass of vegetable remains.

It will readily be understood that all these progressive changes are accompanied by a decrease in the specific gravity of the timber, for the fungus decomposes the substance much in the same way as it is decomposed by putrefaction or combustion, *i. e.*, it causes the burning off of the carbon, hydrogen, or nitrogen, in the presence of oxygen, to carbon dioxide, water, and ammonia, retaining part in its own substance for the time being, and living at its expense.

(*To be continued.*)

A ROTARY THERMOMETER.

THE apparatus shown in the accompanying engravings was devised by Mr. Rabinovitch. It is a new style of thermometer, of great sensitiveness, which rotates around its axis through the variations in position that its center of gravity undergoes. The apparatus consists of a glass cylinder, *a* (Fig. 2), filled with a sufficiently dilatable fluid, such as alcohol or some gas. This cylinder is prolonged into a circular tube, *b b'*, which contains a certain quantity of mercury.

The cylinder, *a*, which is mounted upon an axle, *c*, revolves around the latter when the center of gravity of the device changes position as a consequence of the displacement of the liquid and mercury in the tube, *b*, caused by a variation in the temperature. The axle is provided with two needles, *d* and *e*, mounted with slight friction. The extremity, *b*, of the circular tube is provided with a metal cap, *g*, terminating in a point, *h*, that serves as an index, and that moves over a graduated dial, *i i*. In its motion the index, *h*, carries along the needle, *d*, when it turns from right to left, or the needle, *e*, when it turns from left to right. This index marks the degree of temperature of the surrounding air at every moment. It cannot move the needles back to their original positions, and the latter

FIG. 1.—RABINOVITCH'S ROTARY THERMOMETER.

will therefore mark respectively the maximum or minimum temperature during a period of observation.

At any desired point on the dial, *i*, is placed an electric contact, *k*, designed to actuate a bell, *l*, when the point, *h*, closes the circuit. For example, on placing the contact at 30° on the dial, the point, *h*, on reaching this division, will close the circuit and actuate the bell.

Upon adding still another contact to the right of the dial, the inventor obtains a maximum and minimum telltale. On placing one contact at 25° and the other at 15°, the apparatus always announces, through the bell, when the temperature has reached one of these limits. This application may prove very useful, from a hygienic or industrial standpoint.

It remains for us to remark that the tube, *b b'*, is provided at its lower part with an appendage, *m*, that carries a pencil, *n*. This latter, which follows the motions of the tube, moves in front of a sheet of divided paper to which a downward motion is given through clockwork. Under such circumstances, the abscisses marking the temperature and the ordinates the time, we shall obtain a diagram of the variations in temperature during a determinate period.

Perhaps no instrument has attracted the attention of physicists so much as the thermometer, the uses of which are so numerous. After making known a new progress in the construction of this valuable apparatus, it will be of interest to sum up the preceding stages in the history of its invention. At the beginning of the seventeenth century, Drebbel invented the air thermometer, which was submitted to the variations of barometric pressure. Fifty years afterward, the

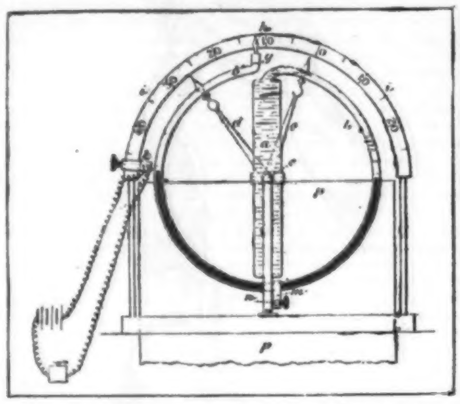


FIG. 2.—DETAILS OF THE INSTRUMENT.

Academie del Cimento constructed an alcohol thermometer such as we have at present, although it had no fixed points. Half a century later, Amentous found that water boiled at a fixed temperature, which he applied to his compressed air thermometer constructed in 1702. This instrument was abandoned on account of its great bulkiness, and because the various instruments did not agree in the indications that they gave. Delisle constructed a mercurial thermometer with two fixed points, one the temperature of boiling water, and the other that of the cellars of the observatory. It is to Newton that we owe the idea of taking boiling water and melting ice as the extreme points of the temperatures shown by the thermometer. It will be seen that the measurement of temperatures has occupied the greatest minds.—*La Nature.*

OIL OF CAMPHOR AND OIL OF SUNFLOWER.

By C. T. KINGZETT, F.C.S., F.I.C.

THIS was the sixth of a series of papers lately read before the Society of Chemical Industry, London, on the oxidation of essential oils, and it referred more particularly to the atmospheric oxidation of turpentine, camphor oil, and oil of sunflower. As regards camphor oil, Yoshida a few years ago stated as the result of an examination of a five years' old sample that the oil consists of terebinthene, citrene, camphor, and a body which he called camphorogenol. The last named body is the most interesting, for Yoshida gave it as his opinion that from it camphor is formed, and that it itself is a product of the oxidation and hydration of terpenes. Mr. Kingzett could not, however, regard Yoshida's experiments as conclusive, and his observations on the oxidation of the oil in presence of water showed that peroxide of hydrogen was freely produced. For instance, 120 gallons of the oil during fifty-two hours' oxidation yielded 1,000 grammes of the peroxide. And on another occasion, 320 gallons yielded 3,379 grammes, calculated as pure H_2O_2, and more was afterward obtained. After quoting figures showing the production of oxidized oil from camphor oil, the author proceeded to show that the formation of peroxide of hydrogen follows the production of camphoric peroxide. It is possible that this may be identical with camphorogenol, in which case peroxide of hydrogen would be formed thus:

$$\underset{\text{Camphorogenol}}{C_{10}H_{16}O_2} + H_2O = H_2O_2 + \underset{\text{Borneol}}{C_{10}H_{18}O}.$$

This, however, is hypothetical, and it is more likely that the peroxide is formed as the result of the reaction of water upon a more highly oxidized body, such as $C_{10}H_{16}O_4$, which yields along with peroxide a bitter substance—$C_{10}H_{16}O_3$—actually found by the author in previous experiments, and in these. It is possible that this substance has the formula $C_{10}H_{16}O_2,H_2O$, and the author calls it "soluble camphor." A sample of it was exhibited. It is a brown, tenacious substance, with a peculiar odor. A sample of oxidized camphor oil was experimentally shown by the iodine test to contain hydrogen peroxide in apparently as great abundance as oxidized turpentine. As regards the soluble camphor, the author thought there was a relationship between it and the thymol-like body which is obtained as the result of the oxidation of turpentine. He had been unable to obtain ordinary camphor from this body. In concluding Mr. Kingzett called attention to the importance of the subject in connection with natural sanitation.

He has in "Nature's Hygiene" given an account of the immense influences on climate which are exercised by pine and eucalyptus forests wherever they exist. In the case of Australia, Mr. Bosisto has calculated that in New South Wales and South Australia there may be held no less than 968,887,440,000 gallons of eucalyptus oil at one and the same moment in the leaves of trees more or less massed together and occupying a belt of country over which the hot winds blow. Accepting this estimate, Mr. Kingzett calculates that this quantity of oil can give rise by its oxidation to the production of 92,785,023 tons of hydrogen peroxide and 507,587,945 tons of soluble camphor ($C_{10}H_{16}O_3$). Considering their powerful oxidizing and antiseptic properties, it is easy to understand how large an influence for good they must exercise upon the sanitary condition of the country in which they are generated. Camphor oil is equally effective with eucalyptus and pine oils, and it follows that within the limits of the existence of camphor forests they may be regarded as constituting a natural sanitary agent of the same high order as forests of pine and eucalyptus trees. As regards sunflower oil, Mr. Kingzett said that he had not obtained any peroxide of hydrogen from it, but he did not know whether the sample was produced from the seeds of the sunflower or from the leaves.

In the discussion on this paper, Dr. C. R. A. Wright said that some years ago he had examined camphor oil and found that it was of very variable composition. From one sample he had obtained a hydrated turpene, $C_{10}H_{18}O$, and if that still existed in camphor oil it would, on the absorption of oxygen, be changed to camphor. He had recognized a similar body in dementholized Japanese peppermint oil. Mr. Thomas Christy said that he had resided in China, and had seen camphor collected. As first obtained it was in the form of an oil, which, however, did not keep liquid, so the natives added other oil to it. But they had stopped that since they learned how, by blowing air into the oil, they could make camphor from it. Mr. Kingzett, in replying to these remarks, said that if the people blew air into camphor oil in China they ought to pay him a royalty, for that was his process. (Laughter.)

The next paper was on

A NEW SERIES OF COTTON COLORING-MATTERS.

Instead of reading the paper, the author, Mr. Arthur G. Green, gave a demonstration in dyeing. The paper was of little pharmaceutical interest, but a brief description of the discovery may be given. Cotton dyestuffs are of two classes: those which combine with the fiber and those which may be regarded as pigments or lakes. To the former belong such substances as methylene blue, annatto, and the diamido bases; and to the latter alizarine and the old mineral colors. The combination of the two classes was aimed at by the author, and this he obtained in *primuline*, an amido-sulphonic acid, which is a yellow powder very soluble in water. It imparts a primrose shade to cotton, and fabric thus dyed is capable, by merely immersing in developers, of changing into all shades from orange to black, according to the nature of the developer. This property depends upon the deazotization of the primuline, and combination with phenols and amines, whereby azo colors are produced. The author's demonstration, which took up the better part of an hour, proved the extraordinary simplicity and utility of his invention. The paper was also a good proof of the value which the study of organic chemistry is in the arts, for Mr. Green's dyeing experiments were nothing more than chemical experiments, complex, no doubt, and involving an intimate knowledge of the most intricate part of organic chemistry. But to produce a new series of dyes is something worth working for, and Mr. Green, who is quite a young man, has that satisfaction.

EXAMINATION OF CASCARA SAGRADA (RHAMNUS PURSHIANA).*

RECENT investigation of the constituents of cascara sagrada has led to the discovery of new principles and facts of great importance, pharmaceutically and therapeutically.

The chief objection to cascara sagrada heretofore has been its inherent bitterness. In the light of recent researches tasteless preparations of this drug highly efficacious medicinally are now to be had.

These discoveries mark a distinct advance in pharmaceutical attainment and in the therapeutics of chronic constipation, since this remedy can now be much more generally and persistently administered, and its well-known tonic laxative action obtained without the drawbacks which seemed formerly inseparable from its employment.

The facts disclosed concerning this remedy deserve more than a passing notice, especially since they indicate the existence of principles and modes of action extending far beyond the subject indicated, and are well worth the close attention of the thoughtful and scientific physician. A valuable contribution to the knowledge of the chemical constitution of this drug appeared in the *American Journal of Pharmacy* for February, 1888, which makes it possible not only to obtain a true interpretation of the various clinical observations, but clears up apparent anomalies, and also indicates the reasons for observed effects, which have lately been disputed, but now admit of no further question or misunderstanding.

Among the discoveries referred to in this valuable paper, of especial interest to the physician, is the influence of a class of vegetable ferments, and their recognition as the cause of various abnormal conditions, such as colic, vomiting, nausea, diarrhœa and dysentery, which occasionally attend the administration of certain drugs.

It appears that frangula bark, when fresh, contains such a ferment in excessive quantities, and is therefore unfit for use until the ferment has exhausted itself—the process occupying several years. It also appears that cascara contains some of this principle, and this fact will account for the occasional untoward effects of the drug, which have been observed as consequent on the employment of a number of its preparations heretofore in the market. These effects are, therefore, not due, as has been supposed, to any idiosyncrasy on the part of the patient, or to the laxative or tonic constituents of the bark itself, but to a distinct objectionable principle, which once recognized can be rendered inoperative and harmless.

It has been reserved for Parke, Davis & Co., through their exhaustive investigations, to be the first to clearly recognize the principles involved, and by the application of such intelligent comprehension, to formulate and adopt correct pharmaceutical processes, and thus overcome all the difficulties heretofore existing. As a result of their investigations they now offer to the medical profession a fluid extract, a solid extract, and also a concentration, all of which (designated as "Formula of 1887") exhibit only the desirable laxative and tonic properties, and being free from this ferment

* Abstract of an article entitled "An Examination of Cascara Sagrada," by H. F. Meier and J. Leroy Webber, "American Journal of Pharmacy," Feb., 1888.

are incapable of producing griping, nausea, or any of the usual effects above enumerated.

It appears that these ferments are distributed through a large number of vegetable substances, not being confined to unripe fruits only, but can also exist in the root, bark, leaf, or even in vegetable extracts, of which we have illustrations in various juices, liquid or inspissated. Of this latter class aloes will serve as an example. A familiar illustration of an unaltered vegetable would be the cucumber, the green apple (familiar to the school boy), and unripe fruit generally. In the case of the cucumber, experience has taught the means of removing this ferment by dialysis or osmosis. We sprinkle salt over it or surround it with a strong brine, which provokes an outward flow of the fluid containing the ferment, with the result that the ferment is to a large extent removed, and thus rendered incapable of producing the same conditions in the stomach, for which it was intended in the plant; that is, the creation of vegetable acids from other material previously existing, in the same manner that pepsin, likewise an unorganized and soluble ferment, provokes the solution of fibrin and albumen, forming peptone, or as diastase is capable of effecting the transformation of starch into soluble glucose and dextrin, both new bodies.

That these ferments all bear a direct quantitative proportion to the results accomplished, has been practically recognized. We are promised a satisfactory indication of the sources of the acids formed in the plant, which will enable us to corroborate the statements that identical processes go on in the stomach when the ferment is permitted to exert its action there.

THE PRESENT POSITION OF TOXICOLOGY.*

By J. O. ARNOLD, F.C.S.

IN considering this subject it may be remarked at the outset that popularly the powers of the analyst with reference to the *post mortem* detection of poisons are much exaggerated, and the skill with which it is supposed he is always able to separate and estimate fabulously minute quantities of any poison exists only in the imagination of the ignorant. True it is that a limited number of poisons can be detected with certainty, when only mere traces are present, but the detection and estimation of the majority of vegetable poisons are environed respectively with great difficulty and doubt. It is proposed to deal only with those poisons (excluding corrosive substances) which, from their frequent use in medicine, are likely to be of interest to pharmacists. Such poisons may be divided into two groups: (*a*) poisons detected with difficulty, (*b*) poisons capable of easy separation and recognition.

Group A.—Colchicine, aconitine, digitalin, atropia, cantharidin, morphine (opium).

Group B.—Strychnine, prussic acid, arsenic.

First taking into consideration the members of group A, the initial step of the analyst is to endeavor to completely isolate the poison from the mass of organic matter with which it is usually associated. The process for the separation of alkaloids generally is as follows: The highly concentrated organic liquid or finely pulped solid is digested for many hours at a gentle heat with excess of rectified spirit containing a little acetic acid; the alcoholic filtrate is then highly concentrated on the water bath, and everything soluble dissolved out with water. To the aqueous filtrate a general test for alkaloids may be applied, such as sodium phosphomolybdate or the chloriodide of potassium and mercury, when, if any appreciable quantity of an organic base is present, a yellowish precipitate is obtained. But it must be remembered that albuminous and certain other organic substances give a similar result, to say nothing of the poisonous or nonpoisonous organic bases, which are now known to develop spontaneously in a dead body, and which have been isolated in the pure crystalline state in such quantities that many elementary organic analyses have been made to determine their formulæ. In the face of these facts no analyst is justified in future in stating that extraneous alkaloidal poison exists in a dead body because he has obtained a precipitate with a general reagent. It is necessary that the alkaloid should be separated in such quantity, and in a sufficiently pure state, to answer decisively to individual tests. On the other hand, a negative result to the general test indicates that the alkaloids are absent, or only present in quantities so small as to baffle any further endeavor to isolate them. It is obvious that a study of the reactions of alkaloids of *post mortem* development is a subject of vital importance to the toxicologist. It is urgently required that these bases be exhaustively examined to find out if any of them are capable of giving tests coincident with those obtained from vegetable alkaloids likely to be used for criminal purposes; and perhaps, primarily, the most important step is to ascertain whether any of these animal alkaloids yield reactions resembling those of strychnine and morphine.

Returning to the alkaloids of group A (leaving morphine and opium for special consideration) the analyst is confronted by the unpleasant fact that no really decisive chemical tests exist for any members of the group. He may be able to obtain a crude alkaloid contaminated more or less with that brown extractive matter which from its power of obscuring color reactions is the *bete noir* of the toxicologist, but he can do little toward a conclusive settlement of its identity.

Starting with colchicine, we may liberate the alkaloid from the filtrate (to a portion of which a general test has been applied with positive results) by the addition of ammonia, and the crude alkaloid may be removed from the aqueous fluid by means of ether. The residue left after evaporating off the ether is treated with strong nitric acid, and a purplish coloration is supposed to indicate colchicine. But a coloration produced by nitric acid from an organic residue is not, in the speaker's opinion, a test upon which a decision, possibly involving life or death, should be arrived at.

Similarly in the case of aconitine. The crude alkaloid may be obtained by evaporating the ethereal solution, but it possesses no distinctive chemical properties; the only practical test is physiological, namely, that the extract produces a tingling and afterward a sensation of numbness when applied to the tongue. It may here be remarked that all physiological tests are now open to the objection that it has not yet been proved that there are no *post mortem* alkaloids capable of producing similar effects.

Digitalin when isolated gives a few color reactions, *e. g.*, a reddish tint with sulphuric, and a green color with hydrochloric acid; but such are at best only unsatisfactory indications.

For the detection of cantharidi, the vesicating properties of the ethereal extract containing the compound, or in the case of the powdered fly the presence of shining microscopic scales, are the only recognized tests.

The only test for atropine is its well known effect in dilating the pupil of the eye.

Coming now to the more interesting alkaloid morphine, and the opium in which it is contained, the first thought which strikes one on reading records of poisoning cases in which it has been criminally administered, and has afterward been the object of a *post mortem* search, is the fact that its detection is exceptional. Three causes, doubtless, operate to produce this effect. First, morphine is appreciably soluble in water and is not readily removable by immiscible solvents, such as ether or chloroform; secondly, its tests are much obscured by the brown extractive matter always more or less present, any attempt to remove which might be followed by loss of the alkaloid itself in the case of a small residue; thirdly, there is good reason to suppose that morphine is much more susceptible to constitutional alteration in the living body than most other alkaloids. If a small quantity of not very impure alkaloid can be extracted and made to yield the following tests, the presence of morphine is almost certain: (*a*) a moderately strong solution develops a red color on the addition of strong nitric acid; (*b*) the solution liberates iodine from iodic acid, and the former may be concentrated by agitation with bisulphide of carbon into a pink layer; (*c*) sulphomolybdic acid produces when applied to the solid substance a deep crimson tint, changing to dingy green and finally clear blue; (*d*) sulphuric acid and bichromate of potash produce with the solid or a strong solution a green color, owing to reduction of the chromic anhydride to oxide; (*e*) neutral perchloride of iron added to a strong solution of morphine produces a blue or green color.

It must be remembered that with the exception perhaps of the sulphomolybdic test none of these reactions is peculiar to morphine, but it may be safely stated that no other single substance produces all these effects.

The application of dialysis to the isolation of morphine from other organic admixture has been recommended by some toxicologists, but the speaker's experience of the process has been unsatisfactory.

In cases of opium poisoning the presence of meconic acid rather than morphine should be sought for. It may be precipitated as a lead salt; the plumbic meconate after washing is decomposed with dilute sulphuric acid, the filtrate from the sulphate of lead containing free meconic acid is concentrated, nearly neutralized with potash, and a drop or two of ferric chloride is added. Blood red meconate of iron is produced. It must be borne in mind that sulphocyanic and acetic acids give a similar result. In their case, however, the color is destroyed by the addition of dilute sulphuric acid; not so, however, with ferric meconate.

In concluding the consideration of group A, it may be remarked that only in cases where an appreciable quantity of such alkaloids is present in the original organic substance, say about half a grain, can the analyst hope to get decisive results, because these can be obtained only from a moderately pure substance, and the purification of alkaloids inevitably entails loss.

There are cases on record in which operators, miscalled analytical chemists, have certified to the finding of $\frac{1}{100}$ of a grain of morphine; indeed, one has gone so far as to swear to $\frac{1}{1000}$ part of a grain on data manifestly absurd. Such statements excite pain and disgust in the mind of the conscientious and experienced toxicologist.

We now come to group B, and here tread upon firmer ground. Of all the alkaloids, strychnine is the most easily separated, and when isolated is capable of decisive recognition. It may here be stated as a general principle that little reliance can be placed upon the crystalline forms obtained by evaporating on microscope slides the ethereal solutions of alkaloids, because the same base may be made to give several shapes dependent upon the rate of evaporation; neither can a bitter taste form more than a rough auxiliary guide.

In the case of strychnine the characteristic color reactions with sulphuric acid and dioxide of manganese (namely, the production of a play of tints, starting with deep purple and ending with reddish yellow) may be observed with advantage under the microscope with a low power when the base has been isolated in a pure state, but in very small quantity. When a fair amount of alkaloid has been separated, the characteristic chromate may be precipitated in faintly acid solution, washed and dried, when the addition of sulphuric acid alone produces the play of color.

Passing on to the next poison on our list, namely, prussic acid, experience shows that when present even in traces this compound is capable of easy recognition, but owing to its volatile nature (which makes its isolation from the organic matter containing it so easy) it is not often found after the lapse of two or three weeks between death and analysis. Its characteristic odor is often a valuable guide, but when this is not present the poison may be obtained by gentle distillation of the viscera, etc. But it is seldom necessary or advantageous to resort to distillation. If the organic matter containing the poison is placed in a wide mouthed flask, three rapid tests may readily be made, which, taken together, are absolutely decisive. If a drop of nitrate of silver be caused to adhere to a watch glass and the latter is placed over a vessel containing the suspected matter, the application of a very gentle heat causes the vapor of the acid to act upon the silver salt with the production of a white film of cyanide of silver. This film might, of course, be due to other vapors, such as that of hydrochloric acid, and, therefore, this result must be confirmed by other tests. For the drop of nitrate of silver substitute a drop of a solution of potassic hydrate. Potassium cyanide is formed. After a few minutes add to the potash a drop of a mixed solution of ferrous and ferric chlorides. The respective hydrates are thrown down together with the well known cyanide of iron, Prussian blue; on dissolving the former in one drop of hydrochloric acid, the blue flakes of the latter become distinctly visible. The final test should be made with a drop of yellow ammonium sulphide; ammonium sulphocyanide is produced, and on gently evaporating the spot of liquid to complete dryness, the addition of a drop of ferric chloride brings out the blood red color of the sulphocyanide of iron.

We finally reach arsenic, the poison above all others capable of the most certain detection, as its presence in the human body is fixed as the hills; but even with this element the accurate analyst should guard against exaggerated ideas as to his ability to swear to infinitesimally small amounts. It may be stated that the quantity of the metal present, say in half a pint of an organic liquid such as the *post mortem* contents of the stomach, from which decisive and confirmed tests can be obtained, is about 1 milligramme. Less can be detected, but who would care to swear away a life on the strength of the discoloration of a fragment of copper foil by the Reinsch process, or a glimmering speck in the neck of a Marsh apparatus? When, however, a milligramme of arsenic is present in a liquid of the volume and character before mentioned, it can be obtained, as will be shown later on, in an almost pure hydrochloric acid solution, which will yield with the Reinsch test a steel blue color, a decisive deposit in the Marsh tube, and several mirrors on porcelain; the latter are readily distinguished from an antimonial mirror by their instantaneous disappearance when treated with a solution of a hypochlorite. If both the Marsh and Reinsch deposits are sublimed in a tube open to the air, characteristic crystals of As_2O_3 are formed, which may be recognized under the microscope, under a power of about 300 diameters. No data short of the above are sufficient to positively swear to the presence of the poison. The speaker has, however, in a known mixture detected 0·1 milligramme of arsenic in 60 grammes of liver, or $\frac{1}{600000}$ part.

The process by means of which this result was obtained will now be described. Suppose, for instance, we have a portion of the liver of an animal known to have died from arsenical poisoning. The first step is to cut the viscus into small pieces with a sharp knife; the mass is then thoroughly desiccated in the water bath, when it becomes sufficiently brittle to be finely powdered in a mortar, a process more easily said than done. About 15 grammes of the powder are placed in a 250 c. c. flask, provided with a long condensing tube wrapped round with a cloth constantly kept wet with cold water; the end of the condensing tube dips into a small vessel jacketed with cold water, and containing about 10 c. c. of distilled water. The dried liver is thoroughly saturated with pure fuming hydrochloric acid, the cork of the condensing tube is inserted, and the whole is gently distilled until about three fourths the volume of the hydrochloric acid originally added have passed over. The distillate is passed through a small filter, and is, if necessary, somewhat diluted. If arsenic were present in quantity approaching a milligramme, its presence may be decisively proved by both Reinsch and March, and if only one-tenth of a milligramme was contained in the amount of liver taken, a deposit may be obtained in the Marsh tube.

To the student the study of toxicology is rendered difficult by the retention of antediluvian methods in modern works. Roscoe and Schorlemmer, for instance, in dealing with the toxicology of arsenic, reproduce the complicated and dangerous process of Fresenius and Von Babo, a method no analyst would ever dream of using now. The very nature of the process defeats its object from a toxicological point of view, as it is supposed to detect both soluble and insoluble arsenic, whereas the former only is of importance. There is little doubt that by this method traces of arsenic are liable to be found and reported as present in the viscera, which really had their origin in the large quantities of the various reagents used. In the process already described the only reagent used is hydrochloric acid (about 25 c. c.) Of course in cases where quantities of arsenic are present the lemon-yellow sulphide may be precipitated, and to this the various confirmatory tests may be applied. It is a matter of surprise that Roscoe and Schorlemmer should also reiterate the fable of Fresenius that the Marsh test must not be made in the presence of chlorides; a greater fallacy was never penned. As a matter of fact, hydrochloric acid is in all respects superior to sulphuric acid for use in the Marsh test, and the speaker has repeatedly proved that 0·1 milligramme of arsenic in 50 c. c. dilute HCl yields a deposit. Greater delicacy than this cannot be desired. It is not until the student becomes somewhat advanced in his studies that the fact dawns upon him that the beams of light emanating from stars of the first magnitude in the scientific firmaments are not always rich in chemically active rays.

To-night only the detection of poisons has been touched upon, and difficult as is this subject at times, it is easy compared with the unraveling of the mysterious chemical action of poisons on animal life; with effects we are fairly well acquainted, but the corresponding causes are wrapped in the outer darkness which environs the mass of empirics called by courtesy the science of medicine.

* A paper recently read before the Sheffield Pharmaceutical and Chemical Society.

THE INFECTIOUS NATURE OF BOILS—CASE OF PNEUMONIA DUE TO THE PARASITE OF FURUNCULUS.

By Dr. ERNEST CHAMBARD, Paris.

THERE has always been a popular idea that boils are catching, and it has even given rise to the saying that "one boil means nine." The theory of the infectious nature of furuncles has now been proved. There are not only arguments of a clinical order in its favor, such as the reports of epidemics of the disease, and the cases of persons who undoubtedly get it after using basins or objects contaminated by others who had boils, but there are also the results of recent bacteriological researches. A distinct microbe has been found in the pus of boils, which is constant and can be cultivated. There is a good account of it in Cornil and Ranvier's recent book. They describe it as a staphylococcus pyogenes aureus of Rosenbach, consisting of cocci placed in twos, rarely in fours, and often found grouped in large masses. In gelatine and especially in agar-agar a fine orange-yellow cultivation can be produced. They do not look upon it as special to furun-

cles or anthrax, but find it in many suppurative affections, pyemia, osteomyelitis, and puerperal fever.

These micrococci were found in great quantities in a case which Dr. Chambard reports, and which is one which goes far to support the theory. It is that of a general paralytic, who, three months after his admission to the asylum of Ville-Evrard, was found to have a large carbuncle in the back. This was opened and treated locally with iodoform. The carbuncle went on spreading, and two days after the patient died from double apex pneumonia. At the post mortem the lungs were found studded with small yellow nodules the size of cherry stones, those situated near the surface forming small prominences. In some parts where they were very thick, the lung tissue was broken down and small cavities were formed. From these some caseous pus could be squeezed. The very same microbes were found by the microscope in this pus as were found before death in the pus from the carbuncle, and they were the only ones found. They were most abundant in the small hemorrhagic patches.

The presence of these cocci shows the mistake of treating carbuncles with poultices, which by the continued heat and moisture can only tend to favor their propagation, and suggests the wisdom of an antiseptic treatment.—*Progrès Médical*, July 30, August 6 and 13, 1887; *Annals of Surgery*.

PULMONARY CONSUMPTION—APEX EXPANSION VERSUS PURE AIR.*

By Dr. THOMAS J. MAYS.

NEXT to the tubercle bacillus, he said, impure air stood most prominent among the many agencies which had been assigned as the causes of pulmonary consumption. Innumerable plans and methods had been devised and proposed for improving the ventilation of dwellings, hospitals, and workshops. Volumes upon volumes had been written on the ill effects of breathing vitiated air, and the immaculate freshness of the country and mountain air had come to be universally regarded as a certain guarantee against pulmonary consumption. These, like many other popular notions, contained a germ of truth, but actually were delusive, inasmuch as they exaggerated the effects of a small evil, and afforded a false sense of security against the real source of danger in the production of this disease. This he would endeavor to show.

At the very outset he desired it to be well understood that he did not in the least underrate the value of fresh, wholesome air in the prevention and treatment of pulmonary consumption, and, while it was probably true that, on the whole, country people enjoyed greater immunity from this disease than city people—though this was not proved, on account of a lack of adequate statistics—yet he was convinced that the purity of the atmosphere played a very small part in bringing about this probable result. To make a homely, hypothetical proposition, he would state that, if two individuals who respired the same quantity of air, and who were equally well off so far as heredity, food, clothing, warmth, comfort, etc., were concerned, were both enjoined to maintain a sedentary and a stooped position of their bodies for an unlimited period, one in a house and the other outside in the open air, there was no reason for believing that the one inside would fall a victim to this disease sooner than the one on the outside. If the disease was the result of breathing a vitiated and impure atmosphere, how could the fact be accounted for that the inhabitants of Iceland, Greenland, Lapland, and other cold countries of the north, who lived in dwellings notoriously wanting in ventilation, were practically exempt?

Of the Icelanders, Mr. Warnford Lock, who was very familiar with these people and who spoke their language, had said that their life was one long exposure to the elements, and that during the night they lived in dwellings devoid of ventilation, which, if not buried beneath the earth, were built of turf and often became grass-grown. Also that a very bad feature was the excessive stuffiness of the common living and sleeping room, where, owing to the absence of fires, the greatest possible crowding and plugging were necessary in order to maintain a tolerable degree of warmth. And yet Dr. Cullimore, from whose work the quotation was taken, had said that consumption in Iceland was never indigenous, but was always, when it did occur, imported from abroad, and but seldom extended to the second native generation.

On the other hand, it might be stated that the people of the tropical regions of the globe, who enjoyed an uninterrupted reveling in pure, fresh air both night and day, winter and summer, were by no means free from pulmonary consumption. The only difference, so far as the physical life of these two classes of people was concerned, was that the warm climate, which produced such a luxurious atmosphere, also created a tendency to physiological sluggishness and an indisposition toward physical exertion, while the people of the cold and rigorous north were compelled to maintain the warmth and vitality of their bodies in great part, during the day, by physical exercise, of which their occupations of hunting, fishing, herding, etc., gave them a full share.

It was also well known that miners and laborers employed in coal mines, who continually respired an atmosphere which was not only loaded with impurities, but damp and musty, suffered but very little from this disease. One fact which lent color to the belief that pure air was such an essential element in limiting the ravages of consumption was that those who occupied elevated or mountainous regions were less liable to the disease than those who lived near the sea level. Thus, Fuchs had shown from extensive data that at Marseilles, on the seaboard, the mortality from this disease was 25 per cent.; at Oldenburg, 80 feet above the level of the sea, it was 30 per cent.; at Hamburg, 48 feet above the sea, it was 23 per cent.; while at Eschevege, 496 feet above the sea level, it was only 12 per cent.; and at Brotterode, 1,800 feet above the sea, it was but 0·9 per cent. Carrying this line of observation further, it appeared very probable that consumption was almost unknown among any native people who lived more than 6,000 feet above the level of the sea.

What concerned us here chiefly was the reason why mountain climates were, as a rule, so free from pulmonary consumption. Was it because the atmosphere was pure and free from septic germs? This was hardly possible, for if it were true that the aseptic condition of the air played any very prominent part, why should the Icelanders, who nightly reeked in a most filthy atmosphere, or the dwellers along the Nile, who, according to Mr. B. Phillips, lived in huts where the pure air had neither ingress nor egress, except through a small hole near the ground, or the coal miners, who continuously breathed a foul and poisonous atmosphere, all be comparatively free from this disease? Was it due to the general absence of humidity? He thought not, for Bogota, the capital of the United States of Colombia, located on the Andes, near the equator, and at an elevation of over 9,000 feet, was said to be entirely exempt from the disease, although dampness prevailed to quite a large extent. There was much reason for believing that it was principally, if not entirely, on account of the attenuated condition of the atmosphere, and he would, therefore, at once proceed to consider the physiological influence of great altitudes on the human body.

It had been estimated by Dr. Denison that at an elevation of 6,000 feet the surface of the body was relieved of nearly 7,000 pounds pressure. When such an enormous weight was lifted from the body it was quite evident that its interior must also be decidedly affected—the pulse was accelerated from fifteen to twenty beats a minute, the respiration was quickened from ten to fifteen breaths a minute; evaporation from the skin and lungs was increased, and the amount of urine was diminished. These were some of the immediate effects. Protracted residence in such a high region enlarged the chest capacity.

The Quichua Indians, who dwelt on the elevated table lands of Peru, had enormous chests, containing capacious lungs with large air cells. The Mexican Indians possessed chests which were out of proportion to the size of the individual. Dr. Denison had said that children born in the Rocky Mountains had chests of unusually large capacity, and M. Jaccoud had stated that at St. Moritz the respirations were not only more frequent, but fuller. The reason why the number of respirations increased while a person was ascending a great elevation became clear when we took into consideration the fact that at the sea level a cubic foot of dry air contained about 130 grains of oxygen, while at an elevation of 6,000 feet it contained only about 106 grains—nearly 25 per cent. less than a person was accustomed to breathe at or near the seaboard; therefore, in order to supply the wonted amount of oxygen to the body, the respirations must increase either in number or in extent.

From all accounts it was very probable that respiration became accelerated only during the early period of exposure to such an attenuated atmosphere, and that subsequently this function became slow again because the air penetrated deeper and more completely into lung tissue but little called into play before.

That man did not suffer under such a deprivation of oxygen was evident from what we knew to be true of his lung capacity under ordinary conditions of life. Mosso had recently proved experimentally that man possessed a lung capacity nearly one fourth larger than the actual necessities of life at the sea level demanded; hence by employing his whole lung capacity he could extract a sufficient amount of oxygen from this attenuated atmosphere without difficulty. And herein lay the secret of why so many consumptives, and others with weak lungs, derived such great benefit when they resorted to a mountain climate. It might be trite, but it was nevertheless true, that all consumption practically began at the lung apices, because those parts were habitually inactive. They were inactive because, in the first place, the bronchial tubes were so arranged that they conducted the air with greater facility to the base than to the apex of a lung, and, in the second place, because the lung was larger than necessary. Hence the base, which was filled most readily, was filled first, and the apex, if at all, toward the end of inspiration. The apices, therefore, became the superfluous parts of the respiratory organs. It was quite different, however, when the body was immersed in a highly attenuated atmosphere.

Every available space in the chest was now brought into requisition to furnish the needed amount of oxygen, the apices were called out of their lethargic state, the alveoli were inflated, if the infiltrated areas were not dispersed the surrounding alveoli were kept permeable, and so the disease was, at least, limited and called into abeyance. This statement had been corroborated by those who had had large experience in the climatic treatment of pulmonary consumption. Thus, Ruedi had reported that, of 600 consumptives under his care at Davos, expansion of the thorax took place in no fewer than 584. Dr. Denison had said that the increased circumference of the chests of consumptives after undergoing the great altitude treatment had been shown in many of Weber's cases, as well as in his own. Dr. Lindsay had stated that Davos did not cure consumption by its sunshine, or the purity and dryness of its air (although these conditions undoubtedly co-operated in the beneficial effect), but mainly by the rarefaction of its air, which stimulated respiratory activity, promoted healthy expansion and soundness of tissue in the lungs, and hence aided them to resist the spread of morbid deposits.

The fact was of still greater interest that those who followed active employments were less liable to this disease than those who pursued sedentary and quiet occupations. Thus, M. Lombard had found that in Paris, Geneva, Vienna, and Hamburg there were more persons leading a sedentary life afflicted with phthisis than of those leading an active life, in the proportion of 141 to 89. In the Brompton Hospital the relative liability had been found to be 68 per cent. of indoor males to 30 per cent. of outdoor, and all the consumptive females had followed indoor occupations. Dr. Guy had found, in the close workshops of a printing establishment, that the compositors, whose employment was sedentary, fell victims to phthisis in the proportion of 44 per cent. to 31·5 per cent. of the pressmen, who, although breathing the same air and in every other respect subject to the same habits of life, differed only in the active bodily exercise which the press imposed on them; and among the same class of operatives the deaths from the same cause did not exceed 25 per cent. in those who used exercise in the open air.

There could be no doubt, too, that those of our Indians who were still allowed to obey their roaming instincts of hunting and fishing, or to follow their vocation of farming, which a number had done, owed their immunity from this disease, which we knew they possessed, in great part, if not entirely, to the physical exercise which they obtained in this manner, while those who were subjected to the idle and improvident reservation life died rapidly from it, principally because they were deprived of their wonted exercise. This had a direct bearing on the main point at issue. Some of the former class of Indians, like the Pimas, for example, who might be called wild, although they were agricultural in their habits, were living in half underground huts with very little or no ventilation; yet, from all accounts, consumption was an exceedingly rare disease among them.

Thus far it had been seen that, on the whole, those who occupied elevated habitations, as well as those who followed active exercise, were more exempt from the disease than those who lived near the sea level or those who lived a life of quietude. In connection with this he would consider the influence of physical exercise on the lungs, and endeavor to ascertain how it afforded protection against consumption. During physical exercise more oxygen was consumed by the muscles, and more blood and air circulated through the lungs, than during rest. Just how much more air entered the lungs during activity than during rest could easily be estimated when it was known that during inactivity a man breathed 480 cubic inches of air a minute, and while walking at the rate of four miles an hour, or while tramping a treadmill, he breathed 2,400 cubic inches, and if he walked at the rate of six miles an hour he took in 3,260 cubic inches of air a minute.

The difference between 480 and 2,400 cubic inches of air capacity showed that during the exercise of walking, even at the rate of four miles an hour, five times as much lung surface was thrown into action than during rest, which proved very conclusively that bodily activity possessed a marked influence in determining the degree of lung expansion, and that under such conditions regions of lung would be called into service which were never fully reached by air during bodily rest. This was in entire accord with what practically existed. Thus, Darwin had said that the lungs in improved breeds of cattle, which naturally took little exercise and were domiciled much of the time, were found to be considerably reduced in size when compared with those possessed by animals having perfect liberty, and Waldenburg had stated that the vital lung capacity was smallest in persons who led sedentary lives, such as professional men, students, clerks, etc., and greatest in those who followed active outdoor occupations, such as sailors, recruits, etc.

Chassagne and Dally, in their joint work on the "Influence of Gymnastics on the Development of Man," had reported that at the Military School of Gymnastics of Joinville-le-Pont, out of four hundred and one individuals subjected to gymnastic exercises for five months, three hundred and seven, or seventy-six per cent., had shown an increase of an average of 2·5 ctm. in the mammary circumference of the thorax. According to Dr. Abel, seventy-five per cent. of those who practiced gymnastics in Germany experienced an increase in the measurements of the chest. There could be no doubt that the principal reason why consumption increased with the advent of civilization was that everything in civilized life tended to produce physical inertia in our bodies. Walking was replaced by riding in carriages and in cars. Manual labor was in great part done away with by machinery. Active outdoor labor was supplanted by quiet indoor occupations—in fact, everything which tended to produce physical activity was exchanged for a life of ease and indolence. The American Indian, as had already been stated, was known to be comparatively free from the disease in his wild state, but as soon as he acquired the habits and customs of civilized life he became its victim.

Converging the two lines of reasoning thus far developed, it appeared that the immunity from consumption which was established by residing in a mountain climate and by practicing physical exercise was chiefly brought about in the same manner—viz., by increasing the capacity of the chest. And from a practical point of view it was of some moment to know whether the former had more weight in bringing about such restoration than the latter—or, in other words, whether those who lived at great altitudes continued to enjoy this exemption if they refrained from active physical exercise and took up a sedentary occupation in such regions. From recent inquiry into this subject the author was inclined to believe, at least so far as the Rocky Mountain climate was concerned, that, as soon as outdoor pursuits were exchanged for sedentary indoor occupations, consumption increased in frequency. It was, therefore, quite certain that physiological exercise played a more important part in the problem of the prevention and cure of consumption than a residence in an elevated or mountain climate, however valuable the latter might be. We had, moreover, good reason for believing that the immunity which was established by means of physical exercise was more permanent than that which was secured by residing in a mountain climate, for it was a common observation that consumptives flourished at great altitudes only so long as they remained; a protracted stay at the sea level was always regarded as perilous. Such consequences were in perfect harmony with what one would be led to apprehend from a knowledge of the physiological factors involved in the restoration of the patient. These factors were entirely local, and their influence did not extend very far beyond their immediate dominion. This objection did not hold good in regard to physical exercise. One thing might be said, however, in favor of a mountain climate which was not true of physical exercise—viz., it produced its beneficial results without conscious effort on the part of the individual; therefore, when the remedy was viewed from a standpoint of ease and comfort, and not from one of permanence, the mountain climate was to be preferred. In discussing the influence of mountain air, it must not be overlooked that on account of its rarefaction, it increased the circulatory and cellular activity of the body, and in this way undoubtedly aided the process of nutrition; yet even this influence could not be denied to physical exercise, although it was brought about in a more direct and positive manner.

While increased chest capacity was, therefore, the great desideratum in preventing and treating consumption, there was the strongest evidence for believing

* A paper recently read before the Philadelphia County Medical Society.—*N. Y. Med. Jour.*

that it was not so much a question of developing the base of the lungs as of expanding the apices. This was well shown by the fact that the civilized female, although she had on the whole a much smaller chest capacity than the male, yet, owing to her increased costal expansion, which had been cultivated by the protracted influence of tight lacing, she was less liable to pulmonary consumption than the male.

It now remained to be shown how the effects of physical exercise could be obtained without resorting to a mountainous climate. Reference had already been made to the fact that muscular effort increased respiratory motion, and in taking up the question of pulmonary gymnastics it was not the author's purpose to discuss those exercises only which had a direct influence on the chest capacity, but also those which, through the body, had an indirect influence on the pulmonary organs. In all exercises it was very important that none should be carried to the extent of decided fatigue; and that, whenever possible, the body and head should be kept erect, the shoulders thrown back, and the lungs thoroughly filled with each breath; that breathing should take place only through the nose; and that sufficient food should be taken during the intervals. The power of walking was common to most people, and its influence on the lungs, as had been seen, was very marked. It was regarded as of great service even by those who exclusively advocated the utility of great altitude treatment. Dr. Brehmer, of Gorbersdorf, according to Schreiber, had been the first to prescribe, for consumptives, walking up a gradual ascent. A semi daily walk of half an hour or an hour, either on the level or on a slight upward grade, was of immense advantage to the invalid. Running, dancing, skipping rope (especially when the rope was swung backward), bowling, etc., were to be highly recommended. Whatever the mode of exercise, it must be performed under as little compulsion as possible. One reason why the above named exercises were so conducive to health was the fact that the excitement which they induced was so attractive that the consciousness of muscular effort was lost.

Among the many indoor exercises, the following movements were very valuable: The arms, being used as levers, were swung backward as far as possible on a level with the shoulders during each inspiration, and brought together in front on the same level during each expiration; or the hands were brought together above the head while inspiring, and gradually brought down alongside the body while expiring. When a deep inspiration was taken in accordance with either plan and held until the arms were gradually moved forward or downward, or even longer, the process of chest expansion was materially enhanced. Another very effective exercise was to take a deep inspiration, and, during expiration only, the patient was to count as long as possible in a loud voice. A man with a good chest capacity could count up to sixty or seventy, while in a woman with ordinary lungs this power was somewhat reduced. Practice of this sort would gradually develop the chest, and the increased ability to count was a measure of the improvement going on within the thorax. Many of these movements might have their effects greatly enhanced by the use of dumb bells, chest weights, etc., which were made especially for the purpose.

The breathing of compressed and rarefied air was attracting wide attention at the present time in connection with pulmonary consumption, and constituted another most useful method whereby the chest capacity could be decidedly improved. Nearly four years ago Dr. Solis-Cohen, the honored president of our society, had advocated the substitution of compressed and rarefied air for a change of climate, in a paper read before the American Climatological Association. In that paper he had said that in many cases fully as much good could be secured by this treatment as by change of climate, and in a few much more, though in the vast majority of cases in which change of climate was advisable it was but a poor substitute. There could be no doubt that compressed and rarefied air was inadequate when used alone in many cases, but when it was combined with pulmonary gymnastics and other judicious treatment, it was not sure that the results were inferior to those derived from climatic treatment. Recent experience had shown that, when consumptives who had spent one or two winters on the Rocky Mountains or on the Pacific slope without benefit were subjected to the use of compressed and rarefied air in association with other pulmonary exercises, such as had been described, their improvement became marked and decided. On the whole, the author's experience with the air treatment, combined with pulmonary gymnastics, had been very favorable, and he thought that this was in consonance with the observations of others. Thus, the late Professor Flint, in his work on "Phthisis," had said that it did not appear, from the analysis of his cases, that changes of climate had in a marked degree a beneficial influence as compared with the hygienic measures available at home.

The author believed, however, that, as a rule, these measures were applied too infrequently to be of the greatest service; and therefore insisted that the pulmonary gymnastics be repeated every hour and a half during the day—the first thing in the morning and the last thing at night—and for from fifteen to twenty minutes at each time; and that the air inhalations be given at first twice, and in the course of two or three weeks gradually increased to four or five times, a day, and even oftener. It was very true that this method of treatment involved more labor and perseverance on the part of the patient than was required in a high mountain climate; but it was a question whether the patient was not more than repaid by the consciousness that a separation from friends was unnecessary, that the heavy expense, the dangers, and discomforts incidental to travel were avoided, and, above all, that the improvement which might take place would be persistent and practically unaffected by a change of residence.

After reviewing the whole subject, the author had been driven to the conclusion that the line of immunity from consumption, which, in the early history of our country, had been located at the Atlantic seaboard and which had gradually receded westward with the tide of civilization, until at present it had reached Colorado, would not stop until it touched the shores of the Pacific; that the question of curing the disease did not depend on the purity or freshness of the air or upon the number of bacilli which the atmosphere might contain, or upon the amount of oxygen which might be introduced into the body—for these were all secondary considerations; but it was simply a mechanical question—a question as to the best mode of expanding the lungs, and especially the apices of round-shouldered and flat-chested patients, of removing the infiltrated products already existing, and of enhancing the constitutional resistance.

He wished, in conclusion, to make a statement which he should have embodied in the paper, that, according to the latest researches, the apices expanded more in the recumbent than in the erect posture; therefore a person inhaled more air during sleep than in his waking hours.

ELECTRIC MEGASCOPE.

In the magic lantern and the projecting apparatus usually employed, transparent slides have to be used. It can be easily imagined how useful it would prove to have a method of making projections of opaque objects, such as photographs affixed to cardboard, medals, and various apparatus of small dimensions. Under the first republic, the physicist Charles introduced into lecture courses an apparatus called the megascope, by means of which the projection of opaque bodies was effected. The objects placed outside of a dark room were brilliantly illuminated by the sun, and a lens properly fixed in the shutter projected an enlarged image upon a screen. An artificial light was soon substituted for the sun, and at the beginning of the present century the effects produced by the megascope had considerable success. The use of the apparatus was not confined to the projection of statues, bass reliefs, and medals upon a screen, but was extended to the projecting of living persons, who were strongly illuminated by Argand lamps. Since that epoch a large number of megascopes have successively appeared.

Fig. 1.—TROUVE'S ELECTRIC MEGASCOPE.

We shall now make known to our readers an electric apparatus constructed by Mr. Trouve under the name of the anxanoscope. This apparatus, which is lighted internally by means of one or two small incandescent lamps, is very useful for projecting photographs (Fig. 1), drawings, medals, etc. It consists of two cylindrical tubes, fitted together at a certain angle. One of these tubes is provided at its upper part with a lamp and parabolic reflector, and the other contains an ordinary photographic objective (Fig. 2). At the angle formed by the union of the two tubes is placed the object to be projected by reflection on the screen, say a landscape, a photographic portrait as shown in the figure, or a chromo-lithograph. The most remarkable projections are those of medals and coins, and especially the works of a watch in motion.

Fig. 2.—DETAILS OF THE APPARATUS.

There is another model made that differs from the one just described in the addition of a second cylinder containing another electric lamp placed in the focus of a second parabolic reflector. A bichromate of potash battery of four elements, or a battery of Bunsen cells, may be used for supplying the incandescent lamps.—*La Nature.*

DYE WOODS OF THE ARGENTINE REPUBLIC.

Consul Baker, of Buenos Ayres, says that the principal dye woods of the Argentine Republic are the *Quebracho colorado*, the *Algorrobo blanco*, the *Corovillo*, and the *Lapacho*. By boiling the sawdust or shavings of the red *quebracho*, a dark-brown liquid is produced, which, being evaporated to dryness, and cooled, produces an almost black substance, brittle, and of a certain luster, but with which, it is stated, no chemical experiments have been made. For this reason neither its exact chemical composition nor its physical properties are perfectly known, but from its appearance it is very similar to the matter which has long been known to commerce as "dragon's blood." The extract of *quebracho* is used alone to dye wool, as also with such mordants as alum and copperas, or sulphate of copper. In the bark of the very old *Algorrobo blanco* trees a brownish-black sap sometimes runs down, which impregnates it with a resinous and gummy substance that completely dissolves in hot water, thus forming a dark brown tint very similar to the extract of *Quebracho colorado*. By detruncating the trees of the very largest size, a black and extremely bitter sap exudes from the tree, which gradually solidifies in the air. The aqueous extracts made from boiling the wood, and then evaporating to dryness, do not solidify on being cooled so perfectly as those of the *Quebracho colorado*, but form delicate viscous and somewhat tough superficial laminæ. The solution of the coloring matter of the *algorrobo*, without recourse to any mordant, produces very fast colors, not only in wool and silk, but also in cotton and linen goods. The color varies from the clearest to the blackest brown, according to the application. Both the bark and the wood of the *corovillo* appear to contain the same coloring material, which the natives call *tinta punzo*—deep scarlet. The preparation and application of this coloring matter is a secret in the hands of certain families in the interior, who refuse to give to the public any information on the subject. The *lapacho* belongs to the family of the Bignonaceæ, and it is one of the most elegant representatives of the subtropical vegetation of the Northern Argentine provinces. Several species of the *lapacho* are said to exist. The one most common, in the spring of the year, before the new leaves begin to sprout, is so densely covered with flowers that no ray of the sun can penetrate. The wood of this tree is remarkably firm and strong, and for that reason is in very considerable demand. In a chemical point of view the wood of the *lapacho* has also very remarkable qualities; of all the Argentine woods it produces the smallest amount of ashes, which are composed of the salts of phosphoric acid. In the second place, the chemical composition of its organic matter is very complicated. From experiments that have thus far been made it appears that its bark and wood afford about 7 per cent. of tannin, and 7·5 per cent. of coloring matter, which crystallizes well, and about 12·5 per cent. of another coloring matter of less value, since it does not crystallize; also about 5 per cent. of a substance similar to caoutchouc. The latter is insoluble in water,

and the wood long resists decay. It is stated, in fact, that when the wood has remained some time in water, it becomes indurated to such an extent that it is impossible to cut it even with an ax. The following is the method of preparing it for use as a dye wood: A quantity of the sawdust or the shavings is boiled in iron vessels, and ten grains of crystallized carbonate of soda are added for each kilogramme of wood. After boiling for an hour, it is heated two or three times afresh with fresh quantities of water in other vessels. To the liquid extract which results from the portion of the wood already treated, the same quantity of wood and a proportionate quantity of carbonate of soda are added without interrupting the boiling of the liquid. The first portion of the wood already treated is then thrown into the second vessel, which contains the same quantity of water, and to which for each kilogramme of wood five grains of carbonate of soda have been added. After an hour of this treatment the wood of the second vessel is passed to the third vessel, which should also contain pure cold water, and that of the first to the second, and so on. If in the first vessel five kilogrammes of wood to ten kilogrammes of water have been treated, the concentrated extract is thrown into another vessel to cool and to deposit its impurities. Then the liquid of the second vessel is passed to the first one, where it serves to treat fresh portions of the wood, that of the third to the second, and that of the fourth to the third. The wood which was in the fourth vessel is now found to be entirely deprived of its coloring matter. Finally, the water which served to boil the shavings in the first two vessels is added to the cold extract, which is precipitated by crude hydrochloric acid until the liquid colors litmus paper red. A yellowish green substance is precipitated in the crude coloring matter. After filtering it and washing in rain water, it is purified according to the following method: It is dissolved with an equal weight of crystallized carbonate of soda in ten parts of boiling water; the filtered liquid is again precipitated when cold by hydrochloric acid, and the precipitate is washed until the water in which it is so heated does not present any acid reaction. Finally the dried mass is dissolved in boiling alcohol, and after filtering the alcoholic liquid, to separate the last impurities, it is crystallized. By following this method, ten kilogrammes of raw material and seven kilogrammes and a half of pure crystallized matter will be obtained from one hundred kilogrammes of wood, which is soluble in 7·75 parts of boiling alcohol and 85° or in 94·5 parts of cold alcohol. Inasmuch as this coloring matter, hitherto unknown, easily eliminates the carbonic acid of the carbonate of soda, and dissolves into a liquid the color of blood, it is certain that it represents an organic acid. It is for this reason, and in accordance with its origin, that it has been named lapachic acid. This acid, when crystallized by ether, forms very delicate little leaves of greenish yellow color; when crystallized by alcohol the leaves and prismatic crystals are very small, and when crystallized by sublimation, it forms into the finest needles. Consul Baker says that the lapachic acid, its salts, and the products of its decomposition, merit much attention from dyers, because, according to the mordants and the degree of concentration of the flux, they produce very diverse colors in wood and silk; that is to say, whether the articles impregnated by the mordants be at once passed through the flux of the coloring matter or the contrary, or whether they are dyed in cold or heat, the following colors are produced—rose crimson, yellow, clear brown, and dark brown. It appears that nothing has yet been done in the matter of making the dyes and dye stuffs of the Argentine Republic articles of foreign commerce, and Consul Baker says that in spite of the fact that all parts of the country are so rich in these materials, there has scarcely been a movement toward their utilization beyond the meager demands of a few spindles and hand looms in the interior provinces, the people importing all the thread yarns and woven goods used in the country. He also adds that there is certainly a field here for the building up of a large trade in coloring materials, and unless foreign enterprise comes in and takes advantage of the openings which the Argentine Republic offers in the several industries for the production of dyeing materials, they will remain undeveloped for as many centuries in the future as they have in the past. In regard to most of the dye woods and plants, they are found or grow spontaneously in the country, and are immediately accessible along the shores of the Upper Parana and the Paraguay. The *lapacho*, *quebracho*, and the *algorrobo* grow in great quantities and wonderful luxuriance all along these rivers.

THE AKKAS, A PYGMY RACE FROM CENTRAL AFRICA.

AT the last meeting of the Anthropological Institute, Prof. Flower gave a description of two skeletons of Akkas, lately obtained in the Monbuttu country, Central Africa, by Emin Pasha, and by him presented to the British Museum. Since this diminutive tribe was discovered by Schweinfurth in 1870, they have received considerable attention from various travelers and anthropologists, and general descriptions and measurements of several living individuals have been published, but no account of their osteological characters has been given, and no specimens have been submitted to careful anatomical examination. The two skeletons are those of fully adult people, a male and a female, but, unfortunately, neither is quite complete. The evidence they afford entirely corroborates the view, previously derived from external measurements, that the Akkas are among the smallest, if not actually the smallest, people upon the earth. There is no reason to suppose that these skeletons were selected in any way as exceptional specimens, yet they are both of them smaller than any other normal skeletons known, smaller, certainly, than the smallest Bushman skeleton in any museum in this country, and smaller than any out of twenty-nine skeletons of the diminutive inhabitants of the Andaman Islands, of which the dimensions have been recorded by Prof. Flower in a previous paper communicated to the Institute. The most liberal calculation of the height of these two skeletons places that of the male at about an inch below 4 feet, and the female at less than an inch above. We may say 4 feet, or 1·219 meter, as the average height of the two, while a living female of whom Emin Pasha has sent careful measurements is but 1·164 meter, or barely 3 feet 10 inches. The results previously obtained from the measurements of about half a dozen living Akkas are not quite so low as these, varying from 1·216 to 1·420, and give a mean for both sexes of 1·356, or 4 feet 5½ inches. Schweinfurth's original measurements were, unfortunately, lost, and the numbers since obtained are quite insufficient for establishing the true average of the race, especially as it is not certain that they were all pure-bred specimens.

In the list given in the third edition of Topinard's "Anthropologie" (1879), only two races appear which have a mean height below 1·500 meters, viz., the Negritos of the Andaman Islands, 1·478, and the Bushmen, 1·404. Of the real height of the former we have abundant and exact evidence, both from the living individuals and from skeletons, which clearly proves that they considerably exceed the Akkas in stature. That this is also the case with the Bushmen there is little doubt, although the measurements of this diminutive race are less numerous and carefully made.

The point of comparative size being settled, it remains to consider to what races the Akkas are most nearly allied. That they belong in all their essential characteristics to the black or negroid branch of the human species there can be no doubt, in fact they exhibit all the essential characteristics of that branch even to exaggeration. With regard to the somewhat more rounded form of head (the cephalic index in these examples being 74·4 and 77·9, respectively), Hamy has long since pointed out that in equatorial Africa, extending from the west coast far into the interior, are scattered tribes of negroes, distinguished from the majority of the inhabitants of the continent by this special cranial character, as well as by their smaller stature. The Akkas are grouped by Hamy and Quatrefages as members of this race, to which the distinctive name of "negrillo" has been applied. Their small size has naturally led some anthropologists, including Schweinfurth, to ally them to the diminutive African race inhabiting the southern part of the continent—the Bushmen. But beyond certain characters met with in the whole negroid branch, including the frizzly hair, there is little in common between them. The Bushmen are a very strongly marked race, and both their external appearance and osteological characters are so exceptional that they can never be confounded with any other. The natives of the Andaman Islands have also very distinctive characters, which they do not share with the Akkas, whose position all recent investigations show to be that assigned to them by Hamy as members of the negrillo division of the negroid branch of mankind. It is possible that these people gave origin to the stories of pygmies so common in the writings of the Greek poets and historians, and whose habitations were often placed near the sources of the Nile. The name "Akka," by which, according to Schweinfurth, the tribe now call themselves, has, singularly enough, been read by Mariette Pasha by the side of a portrait of a dwarf on a monument of the ancient Egyptian empire.—*Nature.*

EVOLUTION IN CIVILIZED MAN.

THE annual meeting of the Anthropological Society was held on Tuesday evening, March 6. Maj. J. W. Powell, the retiring president of the society, occupied the evening reading a paper, the sixth of a series on the same subject, on the evolution of man. *Science* gives the following abstract:

In the opening portions of his address, Maj. Powell explained the doctrine of evolution as taught in the philosophy of Darwin and embodied in the phrases "the survival of the fittest in the struggle for existence" and "natural selection." "Nature," he said, "gives more lives than she can support; there are more individuals requiring nourishment than there is food. Only those live that obtain sufficient nutriment, and only those live that find a habitat. Of the multitude of germs, some perish on the rocks, some languish in the darkness, some are drowned in the waters, and some are devoured by other living beings. A few live because they fall not upon the rocks, but are implanted in the soils; because they are not buried in the darkness, but are bathed in the sunlight; because they are not overwhelmed by deep waters, but are nourished by gentle rains; or because they are not devoured by the hungry, but dwell among the living. A few live because they are the favorites of surrounding circumstances. In the more stately phrase of the philosophy of evolution, they are 'adapted to the environment.' Evolution, or progress in life, is accomplished among animals or plants by killing the weaker—the less favored—and by saving the stronger and more favored. Many must be killed because there are too many, and so the best only are preserved. Those a little above the average are saved, and this is called 'natural selection.' But this general statement must be followed a little further, that its deeper significance may be grasped."

Major Powell then illustrated the operation of the law of evolution by showing the infinite variety of conditions presented by the earth as the home of living beings, some of the ways in which competition for life is carried on, and the manner in which plants become more perfect, and animals advanced. "The endeavor has been made," he said, "to show what the struggle for existence means, and the part which competition plays in biotic evolution. Competition among plants and animals is fierce, merciless, and deadly; out of competition fear and pain are born; out of competition come anger and hatred and ferocity. But it must not be forgotten that from this same competition there arise things more beautiful and lovely—the wing of a butterfly, the plumage of the bird, and the fur of the beast; the hum of the honey bee, the song of the nightingale, and the chatter of the squirrel. So good and evil dwell together."

Having thus characterized that competition which obtains among the plants and lower animals in the struggle for life, Major Powell continued: "It is proposed to characterize the competition which exists in the higher civilization between man and man, and to show in what respect it may be like, and in what respect it may be different from, biotic, which exists in the lower orders of creation; and for this purpose the savage and barbaric tribes of men will be neglected. Nor will the nations of early civilization be considered, but only mankind as he has obtained the highest civilization at the present time.

"In civilization man does not compete with plants for existence. Thorns cannot drive him from fruits, husks cannot hide nutritious seeds from his eye, shells cannot defend sweet nuts from his grasp; but he speedily destroys from the face of the earth the plants which are not of the highest value for his purpose, and he plants those that are of value, and multiplies them in a marvelous manner, and by skilled culture he steadily improves their character, making the sweet sweeter, the rich richer, and the abundant more abundant.

"In the higher civilization, man does not compete with the beast for existence. There are no howling wolves or bears on our farms, there are no lions or tigers in civilized lands, and there are no serpents in our cities. All these dwell where civilization has not yet conquered its way. Civilized man has domesticated the animal; he hives the bee for its honey, he coops the bird for its eggs, he pastures the cow for her milk, and he stables the horse that his boy may ride on its back.

"In the highest civilization, the world is not crowded with human beings beyond their ability to procure sustentation; for, if some hunger, it is not because of the lack of the world's food, but because of the imperfect distribution of that food to all. Men are not crowded against plants, men are not crowded against beasts, and men are not crowded against one another. The land is yet broad enough for all. The valleys are not all filled, the hillsides are not all covered. The portion of the earth that is actually cultivated and utilized to supply the wants of man is very small: it compares with all the land as a garden to a plain, an orchard to a forest, a meadow to a prairie. Nature is prodigal of her gifts. The sweet air as it sweeps from zone to zone is more than enough to fan every cheek; the pure water that falls from the heavens and refreshes the earth, and is again carried to the heavens on chariots of light, is more than enough to refresh all mankind; the bounteous earth, spread out in great continents, is more than enough to furnish every man a home; and the illimitable sea has wealth for man that yet has not been touched. Thus it is that in human evolution over-population is not a factor, as it is in biotic evolution.

"In the highest civilization, man does not compete with man in the struggle for existence, and thus human competition is not biotic competition. In biotic evolution the wolf devours the fawn; but on the average he devours the weakest fawn, and the strongest fawn lives to beget a fleeter race of stags; and the evolution of stag life is accomplished by such means. But when the highwayman waylays the traveler, and there is a struggle for existence which ends in a murder, no step in human evolution is accomplished thereby.

"Again: in the higher civilization, man does not compete with man in the direct struggle for the means of existence as does the brute. In the struggle for subsistence, one ox gores another to drive him from a blade of grass, one wolf rends another to drive him from a bone. Among the animals the struggle for the means of existence is direct, rapacious, and cruel; but in civilized society man shares with his fellow man; the poor and unfortunate are fed at the table of charity. A maimed beast is driven from the crib, but men and women will vie with one another to serve a maimed man; and one of the highest aspirations of civilized society is to dispense generous hospitality.

"Vestiges of brutal competition still exist in the highest civilization, but they are called crimes; and, to prevent this struggle for existence, penal codes are enacted, prisons are built, and gallowses are erected. Competition in the struggle for existence is the agency by which progress is secured in plant and animal life, but competition in the struggle for existence among men is *crime* most degrading. Brute struggles with brute for life, and in the æons of time this struggle has wrought that marvelous transformation which we call the evolution of animals; but man struggles with man for existence, and murder runs riot; no step in human progress is made.

"That struggle for existence between man and man which we have considered and called crime is a struggle of one individual with another. But there is an organized struggle of bodies of men with bodies of men, which is not characterized as murder, but is designated as warfare. Here, then, we have man struggling with man on a large scale, and here it is where some of our modern writers on evolution discover the natural law of selection—'the survival of the fittest in the struggle for existence.' The strongest army survives in the grand average of the wars of the world.

"When armies are organized in modern civilization, the very strongest and best are selected, and the soldiers of the world are gathered from their homes in the prime of manhood and in lusty health. If there is one deformed, if there is one maimed, if there is one weaker of intellect, he is left at home to continue the stock, while the strong and the courageous are selected to be destroyed. In organized warfare the processes of natural selection are reversed; the fittest to live are killed, the fittest to die are preserved; and in the grand average the weak, physically, mentally, and morally, are selected to become the propagators of the race."

After illustrating this point at some length, Major Powell said that it must now be shown what man has done with this law of evolution.

"A river has a precipice in its course, and where the water falls there is danger to man. The Indian, drifting in his canoe too near to the brink, is carried over the cataract, and his bones are left to bleach upon the rocks below. But at the same place the civilized man finds a power, and about the cataract he builds a city, and with the cataract he runs his mills and factories, and that which was a power of destruction to the savage is a beneficent agent in civilization.

"Two summers ago a young friend of mine, with two comrades, was sailing in a boat on Yellowstone Lake. As he neared the shore a little cloud spread overhead; then something happened that the members of the party knew not, for it came as an instant flash. Some time after the flash of unconsciousness, my friend, who was the leader of the party and the captain of the boat, opened his eyes once more to the light of day, and the sail of his little boat was all ablaze, and the mast was on fire, and a hole had been pierced in the bottom of his boat, and the waters of the lake were boiling up to fill it, and the gunwales of the boat were sinking down to the water's edge, and before him in the boat were two prostrate forms—one paralyzed

by the lightning stroke, and the other dead from the lightning stroke—and he himself had his right arm seared by the terrible bolt; and the boat sank, but in shallow water; and the living struggled out to land, and the maimed buried the dead on the shores of the lake in the land of the beautiful. How terrible is the lightning stroke! I had another friend whose daughter was stricken with dire disease, and the wife and mother started with the invalid daughter to go beyond the seas, hoping that the mild breezes of the Mediterranean might waft the balm of healing to the loved one while she dwelt on Italian shores; but as the loved ones sailed away, and were lost behind the curve of the world, a great fear come over the heart of my friend that his loved daughter would not live to reach the farther land. Day by day the fear grew; but one day a flash of lightning came from beyond the sea through the ocean depths, and brought him a message of their safety. So the genius of man has transformed the very lightning of destruction into a messenger of love and joy.

"It is in the same manner that the genius of man has transformed this brutal, this cruel law of evolution into a beneficent agency for his own improvement; and to explain this is our delightful task.

"From the dawn of human culture in savagery to the midday of culture in civilization, human genius has been producing many inventions for many purposes, and the good have given place to the better, and the better have yielded to the best.

"A sheep gathers the grass with his teeth, the ox with his tongue, and the horse with his lips; and teeth, tongues, and lips are modified and developed as these animals struggle for existence. But the savage, just a little higher than the brute, walks through natural meadows, and with a stick in one hand beats the grain from the stalks of grass into a basket held in the other; then, to separate the grain from the chaff, he tosses it on a tray, that the passing breeze may cleanse it; then the grain is roasted, and ground between stones, one lying on the ground, and another held in the hands—two mealing stones; and the flour is spread on a stone, and baked into a cake on the coals. So stick and basket and tray and mealing stones and baking stone are the implements and devices for gathering and preparing the cereal food of the savage. Then man invents a reaping hook, then a grain cradle, then a reaper; and in the process of invention from the sickle to the reaper, what a multitude of inventions are developed! Along this course how many tools, implements, and machines become obsolete and useless, that the one great reaper may remain! Here it is that we have 'the survival of the fittest in the struggle for existence;' and man, by his genius, transfers this struggle from himself to the work of his hands. The way from basket reaping to power reaping is long, but all the steps that way have been taken in the endeavor of mankind to secure greater happiness."

Major Powell also illustrated the evolution of the power thrasher from the flail, of the most improved winnowing machine from the fanning tray, of the steam or water power flouring mill from the mealing stones, etc.

"The sheep, the ox, and the horse make their struggle for existence with their teeth, tongue, and lips; but mankind has passed beyond the stage where he must struggle for existence, into that condition where he endeavors to secure greater happiness. Tongue, teeth, and lips are no longer developed along the line of animal evolution; but human evolution is established by the development of human arts, and this struggle for existence is transferred to painless objects."

This truth was further illustrated by describing the evolution of the chronometer from the clepsydra and the hour glass, and of the ocean steamship from the raft.

"Among bisexual animals, one of the agencies of evolution is sexual selection. Brutes fight with one another for mates, and in the grand aggregate the weaker are killed, and the stronger are preserved to perpetuate their kind; and various devices are gradually developed for attracting and winning mates, and the forms, colors, and habits of animals are modified thereby. But even in savagery this battle for sexual love is largely avoided, and, that peace may be preserved, marriage institutions are established. It seems at first that men in groups agree to marry women in groups. A group of men holding a group of women in common, defend one another's rights from violation from without, and live together in peace. On this plan there supervenes another system of institutions for marriage, where a group of men are destined to become husbands of a group of women in severalty, and the selections are not made by the parties themselves, but by the elders; that is, where marriage is by legal appointment within prescribed groups. Thus marriage institutions change from age to age, and from state of culture to state of culture, until the highest civilization is reached, where the man marries the woman of his choice on the sole condition that he is the man of her choice, and where the man must have but one wife, and the woman but one husband, and the twain are one in love, in purpose, and in law. But in the course of this evolution of marriage institutions, how many customs have obtained, how many agreements have been made, how many laws have been enacted! And along the entire course of the history of marriage institutions, customs and laws have disappeared, that new and better customs and laws might take their places; and the struggle for mates existing among the lower animals has been replaced by the endeavor to secure peace and happiness in human society. Thus man has transferred the struggle for existence from himself to his institutions. The marriage ceremony of the beast with his mate is a battle with a rival; the marriage of a man with his mate is a festival of kindreds and friends. And wherever any vestige of the beastly struggle remains in human society, there crime is committed, and the course of human evolution is checked. The way from communal marriage to monogamy and personal choice is very long, but every step in it has been taken by man in his endeavor to secure greater happiness."

The evolution of institutions was further shown by the establishment of authority, the history of which was traced from the elder right through the right of the noble, by constant and long endeavor, into the right of the representative.

"Comparing animals with men, among the brutes rights and duties are distributed by hoofs and claws and horns and fangs, and by all brutal powers; but among men rights and duties are distributed by institutions.

"In this brief review of the growth of institutions, it is observed that forms of government are ever changing, that the constitution of the state is ever changing, and that the laws are ever changing. As these changes proceed, better institutions are selected by men; and thus is secured a 'survival of the fittest in the struggle for existence' among institutions. In civilization man does not struggle with man for existence; but by the invention of institutions he emancipates himself from the reign of terror inherent in brutal competition, and transfers the struggle from himself to the institutions of his creation.

"All of this statement may be summarized in this manner: man does not compete with plants and animals for existence, for he emancipates himself from that struggle by the invention of arts; and, again, man does not compete with his fellow man for existence, for he emancipates himself from that brutal struggle by the invention of institutions. Animal evolution arises out of the struggle for existence; human evolution arises out of the endeavor to secure happiness. It is a conscious effort for improvement in condition.

"But arts and institutions alone have not secured the evolution of mankind, for they have been powerfully aided by two other classes of human invention—namely, linguistics and opinions—and the part which they have taken must be mentioned."

Major Powell then showed that the same struggle for existence, and the same survival of the fittest by human selection, which have been found among inventions, and again among institutions, may be discovered among languages and linguistic methods and devices.

"By human endeavor, man has created speech, by which he may express his thoughts. And out of this endeavor, in all lands and in all time, the unorganized languages of savages have been developed into the languages of modern civilization; and all this progress, all this evolution, is by human endeavor; and in it natural selection, as that term is understood in biology, has played no part.

"Along the course of human progress opinions have been changing. The cruelty of nature in biotic evolution has been set forth. In this figure of speech, Nature is personified, and, if we still personify Nature, to the savage man Nature was ever a deceiver and a cheat.

"Nature tells the savage that the earth is flat, over which the sky is arched as a solid dome; then Nature tells the savage that the sun travels over the flat earth, and under the sky of ice, by day from east to west, and returns again in a cave by night from west to east; then Nature tells the savage that the rain comes from the melting of the ice of the sky. Many, strange, foolish, and false are the stories that Nature tells to the untutored savage. Nature is the Gulliver of Gullivers, the Munchausen of Munchausens. Nature teaches men to believe in wizards and in ghosts. Nature fills the human mind with foolish superstitions and horrible beliefs. The opinions of the natural man fill him with many fears, give him many pains, and cause him to commit many crimes. Out of all these savage superstitions, man has traveled a long way into the light of science. And how shall the opinions of modern civilization be characterized? And who can tell how the knowledge of the highest civilization transcends the knowledge of the lowest savagery? And so opinions have been changing—old opinions have died, and new opinions have been born—and philosophies have struggled for existence as man has endeavored to learn; and with man forever the struggle to know has been the endeavor to secure happiness, for truth is good, and wisdom is joy.

"Attention has already been called to the fact that among the lowest forms of life there exists a marvelous rate of reproduction. As life advances, and plants and animals are developed, the powers of reproduction are curtailed, until man in the highest civilization and in the highest culture of that civilization is reached, when the rate of reproduction is at a minimum. In this state of culture the transfer of the struggle for existence from man to the works of his creation is completed. With this transfer there occurs another of wonderful nature. The marvelous powers of reproduction are transferred from the body of man to the soul of man, and he multiplies his intellectual creations at an amazing rate. Arts are multiplied to secure the joys of life, institutions are multiplied to secure justice, linguistics are multiplied to secure mental communication, and multiplied truths are discovered, so that the body of science is expanding toward the infinite and toward the infinitesimal.

"Among the lower animals the law of exercise is potent: the organ which is used is developed; disuse leads to weakness, decay, and ultimate loss. In human evolution the same method of progress by exercise is discovered to be one of the important factors.

"Through the inventions of mankind his mind has been developed. If we review the history of the human race, and fully comprehend what mental effort has been put forth to invent the arts of civilization and all the arts that have passed away by being superseded from age to age by better inventions, and fully grasp the mental efforts involved therein, we may comprehend that there is some good reason why the inventor of the electric light is superior to the inventor of the torch, why the inventor of the telegraph is superior to the inventor of the smoke signal, why the inventor of the machine shop is superior to the inventor of the flint factory, why the inventor of the railroad is superior to the inventor of the dog-sled, why the inventor of the newspaper is superior to the inventor of a picture writing on a bone. It has caused some exercise to bring about all the mental evolution which these differences implied."

This exercise of the human mind was further illustrated in the organization and reorganization of states, the enactment of laws to take the places of those that have been repealed, and in the establishment of courts. "To invent and apply human institutions, the mind of man has been forever at work, and out of this exercise has come a share of the evolution of the human intellect.

"Modern industries have been highly differentiated, or, the political economists would say, in modern industry there is great division of labor. By this division of labor men are made interdependent. No man lives for himself, but every man lives for others.

"When a man invents a new thrasher, it is not that he may thrash his own grain, but that his neighbors may use it, that all the world may have it, and they, in return, may contribute to his happiness. If a man invents a new regulation or law, it is not that his own conduct may be regulated thereby, but that some injustice may be removed, or some justice be established, in the relations of the people of the state one to another. The farmer plants a field to raise wheat for his neighbors' bread, the gardener plants the vineyard to raise grapes for his neighbors' wine, the lawyer pleads his neighbors' cause, the physician gives nepenthe to his neighbors' pain, the poet writes for his neighbors' delight, the artist paints for his neighbors' gallery, and the philosopher expounds for his neighbors' instruction.

"All honest men are working for other men. If a man works exclusively for himself, he is a counterfeiter, or a forger, or a sneak-thief, or perchance a highwayman. All love of industry, all love of integrity, all love of kindred, all love of neighbor, all love of country, and all love of humanity, is expressed in labor for others. For this service thus performed a right to a reward is required, and he for whom the service is performed has imposed upon him the duty to render the reward, and the service is rendered in the hope of the reward. Everywhere in civilized society men are thus working for others. Every man, in all the years of his labor, toils for his fellow man, and the practice is universal among all honest civilized men, and lasts from generation to generation; and universal practice is gradually becoming crystallized into universal habit. One man is trying to make better houses for his neighbors, another man is trying to make better shoes for his neighbors, another man is trying to make better laws for his neighbors, and another man is trying to make better books for his neighbors. Every man is thus forever dwelling upon the welfare of his neighbors, and making his best endeavor for their good; and thus the habit grows from generation to generation, until at last some men forget that there is reward for service, and labor for their fellow men because they love their fellow men.

"It has been seen that no man works for himself. The counterpart of this is that every man is dependent upon his fellow man. That he may have good and abundant food, he desires the welfare of the farmer; that he may have good clothing, he desires the welfare of the manufacturer; that his rights may be maintained, he desires the welfare of the statesman, the jurist, and the administrator; that he may have the truth, he desires the welfare of the author; that he may enjoy poetry, he desires the welfare of the poet; and that he may enjoy art, he desires the welfare of the artist. It is thus that man is taught that he who loves the world loves himself, and he who hates the world hates himself. So it is that man toils for others and plans for their welfare, and others toil for him and plan for his welfare, so that every man's good is bound up with every other man's good, and every man's evil is an evil to every other man. And as man forever desires the good of his neighbor for his own sake, from generation to generation the desire for his neighbor's welfare for his own sake gradually becomes the desire for his neighbors' welfare for his neighbors' sake. Thus it is that selfishness is transformed into love, and justice and love are developed into the ethics of mankind. A part of the endeavor of mankind is governed by the principles of political economy, but the greater part is governed by the principles of philanthropy."

Major Powell then discussed competition among civilized men, which differs altogether from that competition which obtains among plants and animals. "It is a rivalry among men engaged in the same vocation to render a service to others that the reward may be received. Economic competition has or may have two factors—emulation and antagonism. By emulation is meant the strife between men for greater excellence, to perform better service for their fellow men. By antagonism is meant strife in which man endeavors to injure his rival that he may himself succeed. Emulative competition results in human progress, antagonistic competition results in human retrogression."

The difference between these two kinds of competition was illustrated by the strife of artists to make the best pictures, by the organization of leagues or schools to instruct one another, and by such an appreciation of common interest in art as leads to great mutual help, and a comradeship that inspires to best endeavors. "Such generous emulation and all its products are in the line of human progress. But jealousies, unjust criticism, carping detraction, and vile slander lead to no progress among mankind. Every success in art creates among laymen an appreciation and love of art in every way beneficial to the artist himself. The natural man, in his ignorance, spurns all works of art; it is the cultured man that loves art; and the culture which brings appreciation and love of art arises from the ethical training which works of art give. In art, demand does not create supply, but supply creates demand. It is thus that the broad-minded artist rejoices in the success of his brother."

Further illustrations of emulative and antagonistic competition were drawn from the professional classes and from those engaged in agriculture. "The clientage of the latter is large and indefinite. The farmer is not striving to serve his neighbor Jones, but to serve the world. The farmers, too, are of great number; that is, there are many servants. For these reasons a farmer does not compete with his neighbor or with a number of specified or known persons, but his competition is with the whole body of farmers. For this reason, too, the spirit of antagonistic competition is never born; the competition of farmer with farmer is purely emulative."

These two kinds of competition were still further illustrated by the experience of the large body of people engaged in mining, manufacturing, and transporting industries. "Among them is both emulative and antagonistic. To avoid the evils of the latter, each class of employers is gradually organizing corporations or trusts; but by these, emulative competition is also avoided, for the managers of business enterprises no longer compete for business, but distribute business by convention. And in the same manner they repeal the law of competition in the labor market; they seek by convention to establish rates of wages. The employes in these same industries also compete with one another

in two ways—by striving to render their labor more efficient by skilled industry, and by offering to labor for smaller wages. The first method of competition is emulative, the second antagonistic. In all civilized society there is no competition so direful in its results, so degrading to mankind, as that which is produced among the employes of these classes who compete for employment by cheapening labor, for it results in overwork which is brutalizing, and in want which is brutalizing, and the abolition of this form of competition is one of the great questions of the day. To avoid the evil, these people organize labor unions, but, while these destroy antagonistic competition, they also result in the destruction of emulative competition. The great problem in industrial society to-day is to preserve competition, and destroy antagonistic competition. The professional classes have already solved the problem for themselves, and they stand aloof and deplore the struggle; but they should learn this lesson from history, that, when wrongs arise in any class of society, those wrongs must ultimately be righted; and so long as they remain, the conflict must remain, and when the solution comes not by methods of peace, it comes by war.

"Injustice is a strange monster. Let any body of people come to see that injustice is done them in some particular, though it may be one which affects their welfare but to a limited degree; they dwell upon it, and discuss it, and paint its hideous form one to another, until the specter of that injustice covers the heavens, and gradually to that injustice the people will attribute all their evils. If a body of laborers receive unjust reward for their toil, they will dwell upon this evil so long, so often, and kindle their passions to such a height that they will at last attribute to the failure of receiving a modicum of reward for their toil all the evils of their own improvidence, all the evils of their own intemperance, all the evils of their own lust; and if fire and flood come, the very evils of unavoidable misfortune will be attributed to the injustice of unrequited toil. Injustice is of such a nature that it must be destroyed by society, or it will destroy society. We dare not contemplate its existence with equanimity, for 'behold, what a great fire a little matter kindleth!'"

One of the most interesting illustrations of antagonistic competition given was that which exists in advertising. "The honest system of advertising should be but a small announcement of the offer of goods for the information of those who desire to purchase in such a manner that those who desire to purchase may, by seeking, find. But in advertising as it now exists, exaggeration is piled on exaggeration, and falsehood is added to falsehood. The world is filled with monstrous lies, and they are thrust upon attention by every possible means. The mails are filled with them. When a man opens his mail in the morning, the letter of his friend is buried among these advertising monstrosities. They are thrust under street doors, and they are offered you as you walk the streets. When you read the morning and evening papers, they are spread before you with typographic display, they are placed among the items you desire to read, and they are given false headings, and they begin with decoy headings. They are posted upon walls, and on the fences, and on the sidewalks, and on bulletin boards, and the barns and housetops and the fences of all the land are covered with them, and they are nailed to the tree and painted on rocks. Thus it is that the whole civilized world is placarded with lies, and the moral atmosphere of the world reeks with the foul breath of this monster of antagonistic competition."

In closing, Major Powell briefly reviewed the history of the land question in Great Britain, the conversion of the commons in England into the estates of nobles, until people learned that wanton extravagance of life is cured by elevating the poor to a higher condition, where they speedily learn the principles of prudential reproduction; and to-day, in that land, statesmen and scholars are devising the means by which those great estates may still be distributed among the poor. He also referred to the movements of wages among the laborers in Great Britain, their reduction to the lowest pittance on the plea in justification of the sanction of the immutable law of competition. Then there arose a philosophy which sought to ameliorate the condition of the poor people by charity. Still later a new philosophy arose, which taught that the wage fund was limited, and was sufficient to supply only a limited number of workers; and so wages were reduced still lower, to be followed by strikes and riots, which threatened the beautiful isle with anarchy. "And now," said Major Powell, "another philosopher has arisen in the world, the great Herbert Spencer; and he has discovered another fundamental principle, a major premise, that human progress is by 'the survival of the fittest in the struggle for existence.' That the fittest may survive, the unfit must die. Then let the poor fall into deeper degradation, then let the hungry starve, then let the unfortunate perish, then let the rich and the wise and the good and the strong live and flourish and propagate the race, then let the ignorant remain in his ignorance. He who does not seek for knowledge himself is not worthy to possess knowledge; and the very children of the ignorant should remain untaught, that the sins of the fathers may be visited upon the children. Let your government cease to regulate industries, and instead of carrying the mails, let them erect prisons; let governments discharge their state-employed teachers, and enlist more policemen. Such is the philosophy of Spencer and his adherents. And they establish journals to advocate these principles, and edit papers to advocate these principles, and they have become the most active propagandists of the day, and the millions are shouting, 'Great is philosophy, and great are the prophets of philosophy.'

"Thus it is that fundamental principles, major propositions, are discovered to justify injustice, and yet forever man is endeavoring to establish justice. How this shall be done I know not; but I have such faith in my fellow man, such towering faith in human endeavor, such boundless faith in the genius for invention among mankind, such illimitable faith in the love of justice that forever wells up in the human heart, that I swear by the eternal truth the problem shall be solved."

Helen of Troy may have had bogus jewels in her ears and false diamonds around her neck when she raised such a fuss in ancient society circles, for it is said that even before Troy was built, emeralds and other jewels were imitated in glass.

THE OUED RIR'.

The Oued Rir', capital Tongourt, is a great oasis in the Sahara of the province of Constantine, to the south of Biskra. It is one of the regions of Africa most copiously supplied with subterranean water. Remarkable borings have been made here since the French conquest, and, thanks to the benefits of an abundant irrigation, a genuine transformation has taken place in this country. In thirty years the oases have quintupled in value, and, as a consequence of their agricultural resources, of the improvement in the state of the natives, and of the complete pacification of the Algerian south, the population of the Oued Rir' has more than doubled. Now, it is outside of the indigenous oases and far from them, in the center of the vast steppes of the region, that new borings are developing water where it was wanting, and are permitting of irrigating land up to the present reputed sterile. This is due to the French, who do not fear to practice agriculture in these far away regions, and who are going, of their own initiative, and at their personal risk, to undertake a great colonizing work in the Sahara. The example of the Oued Rir' is now being followed in the Tunisian Sahara, where a similar colonization is going on, based, like that of the former, on searches for subterranean water, and bringing the uncultivated lands into value by means of irrigation. It is therefore important to obtain some knowledge of the Oued Rir', where Saharian colonization is showing what it is capable of doing.

The Oued Rir' is like a little Egypt, with a subterranean Nile, which, although it has no fertilizing overflows, is at least constant in its discharge. The existence of the Oued Rir' oases is, in fact, connected with the presence of a great reservoir of subterranean water under a high pressure, which may be made to flow in abundance by means of sufficiently deep wells. Numerous spouting wells, some dug by the natives and lined with wood, and others sunk by the French drill and tubed with iron, here and there tap this reservoir, which extends continuously all along the Oued Rir', say 78 miles from north to south. The water comes from a depth of 220 and 250 feet beneath the surface and has a mean temperature of 25° C. It is situated in a very permeable mass of sand, and is covered and kept under pressure by an impermeable mass of marl and sandy marl with gypsum, which the drills have to traverse. As soon as the tool has pierced the covering, the imprisoned water breaks into the drill hole and spruts to the orifice of the metallic tube. The first jet often ascends to a height of several yards. For some days the water carries much sand and many pebbles, and sometimes even large blocks which it vomits to the surface. Then a stable flow gradually takes place, and the water, issuing clear and limpid from the orifice, falls back around the tube.

THE OUED RIR'.

In places the water under pressure has made a passage for itself through the overlying earth and has given rise to natural wells, at the points of emergence of which there are deep abysses, or hillocks comparable to the craters of volcanoes. Such is the origin of many artesian lakes called *behour* (*bahr* 'sea,' *behour* 'seas'), and of almost all the small reservoirs called *chria* ('nest') that are met with on the surface of the Oued Rir'. If a glance be cast upon a detailed map of the Oued Rir', it will at once be seen that the behours and chrias, the native wells, dead or living, and the French wells, the same as the oases themselves, far from being distributed indifferently over the surface of this large plain, are grouped and arranged on the east side of the valley, and it is on this side that the water exhibits its maximum volume and pressure, while toward the west it disappears quite abruptly. It is not a question here, then, of an ordinary or regular sheet of water of a breadth comparable with its length. It is an aquiferous zone elongated from the north to the south and limited at the sides. It is a sort of subterranean artery. The course of this subterranean water is far from being as simple as that of a river in a valley, but, on the contrary, is of the most capricious character, and, to determine it, it took all the experience of Mr. Jus, the director of the borings. The artesian artery winds, with a thousand sinuosities, under the uniform mantle of earth, and exhibits variations in width of from 2¼ to 8 miles. It is not always single, and, in the region of Ourlana, for example, divides to the north and south so as to figure an irregular X.

On the 19th of June, 1856, a memorable date in the annals of the country, the oasis of Tamerna Djedida witnessed the brilliant success of the first French well, and the drill, in the hands of Engineer Jus, produced a magnificent fountain yielding 1,000 gallons of water per minute. This was called the Fountain of Peace. Since then the borings in the Oued Rir' have been prosecuted by the military administration. In October, 1885, the Oued Rir' contained 114 French spouting wells and 492 native ones, and all these united were discharging (including a few natural wells) 63,425 gallons of water per minute. The French wells, tubed with iron, certain of which are thirty years old, have not varied in their discharge since they were driven, and each new series of drillings has annually shown a rapid increase in the total discharge of the disposable water, and the oases have become fertile again. Almost all the palm trees which were old and in bad condition have been cut down and replaced by young trees. New gardens have been planted around the old ones, and the area of the cultivated land has been doubled.

To-day the Oued Rir' has 43 oases, nearly 520,000 palm trees in bearing condition, 140,000 from one year to seven years old, and 100,000 fruit trees. The annual date production represents a value of more than $500,000.

The inhabitants now number about 13,000, distributed through thirty-one centers of population.

Owing to the artesian borings and the railway that is constructing from El Kantara to Mraier and beyond, the Oued Rir' will become one of the most prosperous regions of all Algeria.—*Condensed from Exploration, Gazette Geographique.*

ON THE NUMBER OF DUST PARTICLES IN THE ATMOSPHERE.*

At the beginning of the paper, reference is made to the great advance recently achieved by physiologists, regarding our knowledge of the solid matter floating in the atmosphere, as they have already provided us with a considerable amount of information regarding the number of live germs in the air under different conditions; while we have but little information regarding the dead organic and inorganic particles. The following investigation was undertaken in the hope of bringing the physical side of the subject abreast of the physiological; and in this paper is given an account of a method devised by the author for counting the dust particles in the air, and also some results obtained by means of it.

One difficulty presented in this investigation is the extreme minuteness of the particles to be counted; most of them are not only invisible, but are beyond the highest powers of the microscope. It was therefore necessary to adopt some method of making them visible. The simplest plan of doing this is to put the air—the particles in which we wish to count—inside a glass receiver, and saturate it with water vapor; then to supersaturate the air by slightly expanding it by means of an air pump. When this is done, a fog is produced in the receiver, and we know that each fog particle has a dust particle as a nucleus; if then we counted these fog particles, we would get the number of the dust particles. By this process, however, we would not by any means have counted all the dust particles present, as the fog particles so formed do not represent nearly all the dust particles. If, after time has been given for these fog particles to settle, another supersaturation be made, the receiver will become packed with another set of fog particles, which would require to be counted; and this process would require to be repeated a great number of times before the last particles would become visible and be counted. It is then shown that if there is only a little dust in the air, so that the particles are wide apart, then only one supersaturation is required to make all of them visible. Further, when there are few dust particles present the fog particles are large, and are easily seen falling like fine rain inside the receiver; and it appeared that if these rain drops could be counted, then the solution of the problem promised to be easy.

The following gives a general idea of the method adopted of working out this suggestion. A small glass

* Communicated by permission of the Council of the Royal Society of Edinburgh, having been read to the Abstract Society on February 6, by John Aitken, F.R.S.E.—*Nature.*

receiver was connected on the one side with an air pump and on the other with a cotton wool filter. Inside the receiver was fixed a small stage, about 1 cm. square, on which the drops were to fall and to be counted. This stage was fixed at a distance of 1 cm. from the top of the receiver, it was ruled into little squares of 1 mm., and was examined through the top of the receiver by means of a magnifying glass. To illuminate this stage a gas flame was used, the light being concentrated on it by means of a globular lens full of water. The air in the receiver was pumped out, and filtered air admitted. This air was perfectly dust free, and gave no condensation when expansion was made. Into this pure air was admitted a small and measured quantity of the air the particles in which we wished to count. After allowing a short time for the air to get saturated, one stroke of the pump was made, which supersaturated the air, and brought down a shower of fine rain; while making the stroke with the pump, the stage was carefully observed through the magnifying glass, and the number of drops that fell on a square millimeter counted. This was repeated a number of times, and the average number of drops per square millimeter was obtained, and used for calculating the number of particles in the air. For every drop that fell on the square millimeter, 100 fell per square centimeter; and as there is only 1 cm. of air above the stage that number will represent the number per cubic centimeter in the air of the receiver. Then, knowing the proportion in which the air tested was mixed with pure air, and knowing also the amount to which the air was expanded by the pump, we have all the figures necessary for making the calculation of the number of particles in the air under examination.

In constructing the apparatus the first thing to which attention was given was to design the arrangement of stage or platform on which the drops could be most easily seen and counted. The first stage tried was a small piece of glass mirror, ruled on the back into little squares. This seemed at first to give excellent results, the drops being easily seen on its surface; but on attempting to count them its unsuitableness was at once evident—the confusion produced by the reflected images of the drops caused it to be abandoned at once. Then a mirror of very thick glass was tried, the glass being so thick that the reflected images were out of focus, but it did not give satisfactory results. Very thin mirrors made of microscope glass were then tried, but had to be rejected, because, though they brought the drops and their reflections together, they were unsuitable, being too rough and covered with fine specks on their surface; only the most highly finished glass can be used for this purpose. The arrangement was then altered, and a transparent stage lit from beneath was tried. This stage was made of a small piece of carefully selected glass, and had the fine lines etched on its surfaces. It was, however, abandoned, as it did not give such promise as the mirror arrangement. All difficulties in the use of mirrors were at last got rid of by making them of silver, and now silver mirrors are the only kind used. They are very highly polished, care being taken to keep the rubbing marks in straight lines and in one direction; they are ruled with fine lines at right angles to each other and at 1 mm. apart. When a silver mirror is mounted in its place, properly adjusted and lighted, it appears, when seen through the lens, like a black surface on which the lines are quite distinct, and on which the small drops shine out brilliantly and are easily counted.

Some difficulty is experienced in keeping the stage at the proper temperature. If it is too hot, the drops on falling on it do not adhere, but present a beautiful illustration of the spheroidal condition, as they roll over its surface toward the lower side of the stage, and drop into the ruled lines, in which they continue rolling till quite evaporated. On the other hand, if the stage is too cold it gets dewed, and counting becomes impossible. Directions are given in the paper for mounting and keeping the counting stage in the best working condition.

In working the apparatus, two methods have been employed of mixing the air to be tested with dust-free air. In one, the dusty air is introduced into a flask which communicates with the test receiver by means of a pipe provided with a stopcock. The small quantity of air that is to be mixed with the pure air in the receiver is displaced from this flask and driven into the receiver by means of a carefully measured quantity of water which is run into the flask. In this way the air to be tested can be measured with a fair degree of accuracy, and as the capacity of the receiver is easily obtained, the experimental errors need not be great.

In the other method of working, the test receiver is connected with a small gasometer, and the air to be tested is mixed with pure air in the gasometer. The gasometer used has a capacity of 20 liters, is carefully graduated and delicately hung, so that the air can be measured in it with a considerable degree of accuracy. In working this arrangement, 1 liter of the air to be tested is generally first mixed with 19 liters of filtered air. After mixing, nine-tenths of the mixture is let out, and the gasometer again filled up with pure air, and the mixture tested in the receiver. If the drops are still too close, more air is let out, and filtered air added till the desired condition is attained. There must not be too many particles present, or all of them will not fall when expansion is made. Till experience is gained, a check on the quantity is easily obtained by admitting filtered air, in place of the air from the gasometer, and seeing if any drops appear on expansion; if none, then the correct number has not been exceeded.

After a satisfactory counting stage had been devised, and the apparatus got into working order, testing began, when at once difficulties presented themselves. The numbers counted in the successive tests of the same air agreed fairly well for a number of times, then all at once the process seemed to break down, and from time to time a great increase in the number was counted, far exceeding the errors of experiment. Then all would go right for a time, but only to be followed by failure before long. The first thing suspected for these and for other failures was always the joints of the pipes and the stopcocks, and time after time have the joints been remade with India rubber solution and stopcocks cleaned and greased, but to find that they are almost never at fault.

It was then suspected that the failure might be due to the filtered air, with which we mixed the dusty air, not being perfectly freed from its dust. The filtering power of cotton wool was therefore studied, when it was found that one inch of cotton wool will filter perfectly if the air is passed very slowly through it, but that even twelve inches of cotton wool will not check all the particles if the air is made to rush violently through it. Filters must therefore be tested under exactly the conditions in which they are to be used.

It was, however, found that though the air was only allowed to pass very slowly through even twelve inches of cotton wool, condensation frequently took place if the expansion and therefore the supersaturation was great. It was thought that in this case the failure might be due to an imperfect action of the filter—that, while it checked most of the dust, yet it allowed the extremely small particles to pass, and that these extremely small particles became active centers of condensation when exposed to the high degree of supersaturation used in the tests. It therefore here became necessary to test whether the *size* of the particles has *practically* any effect on the degree of supersaturation necessary to cause the vapor to condense on them. From the investigations of Clerk Maxwell we have theoretical reasons for expecting that the size of the particles will have an influence of this kind, but at present we cannot say that it is sufficiently great to have a perceptible effect in an experiment such as that described.

To test this point the following experiment was therefore made. A little dusty air was mixed with filtered air, and put into the test receiver, and saturated with water vapor. An expansion of only 2 c. c. was made. This caused the formation of a fog. After these fog particles had settled, the air was returned to the receiver, and after a short time another 2 c. c. expansion was made, when other fog particles appeared. After this had been done a number of times, the density of the fog got less and less, and at last entirely ceased. After this an expansion of 5 c. c. was made. This produced a rainy condensation in the receiver, which appeared a number of times on successive expansions being made, getting less and less dense, and at last it also ceased entirely. After all condensation had stopped with the 5 c. c. expansion, the expansion was increased to 10 c. c., when another shower made its appearance, and after one or two expansions all condensation again ceased. After this condition was attained an expansion of 150 c. c. was made with the pump, when scarcely one drop made its appearance.

It is concluded that in the above experiment we have distinct evidence that the size of the particle does affect the degree of supersaturation required to produce condensation on it. Because, though an expansion of 2 c.c. produced a supersaturation sufficient to cause more than one-half of the particles to become visible, yet it required a higher degree of supersaturation to cause condensation to take place on others. It is also concluded from the experiment that the failure of the air to keep clear, in the tests where high supersaturation was used, was not due to the presence of extremely small particles, as an expansion of 10 c. c. is practically great enough to produce a supersaturation sufficient to cause condensation on the smallest particles.

The failures in the tests not being due to the presence of extremely small particles, it is concluded that they are true cases of condensation without nuclei, similar to those referred to in a previous communication. It was thought that, if they were true cases of spontaneous condensation, they might be checked if the expansion was made slowly and free from shocks. And on the other hand any shock would tend to produce condensation in dust-free air if highly supersaturated. On trying this, it was found that no condensation took place if the stroke of the pump was made slowly and steadily, and that if done quickly, and the piston made to strike the cover of the cylinder violently, then copious showers were always produced in the dust-free air. Here, then, was the key to one of the difficulties, and accounted for the occasional increase in the number of the particles counted, many of the drops having no dust nucleus. Failure from this cause is now entirely prevented by causing the air on its passage from the receiver to the pump to pass through a small opening, or better, through a small cotton wool filter. This checks all violent rush of air, and shocks, and keeps the filtered air perfectly free from condensation even when highly supersaturated.

Again, the failure of perfectly filtered air to keep free from condensation was frequently observed after the inside of the test receiver had been newly wetted. It looked as if the newly wetted sides had saturated the air more thoroughly, and that the condensation was due to the higher degree of supersaturation which took place when expansion was made. This class of failures was, however, traced to the manner of wetting the inside of the receiver. If it was done roughly, and the water splashed, then many nuclei were manufactured in the receiver. If it was done quietly, none, and no condensation followed. Another cause of failure was traced to a drop of water getting into the pipe by which the air entered, and the inrush of air tearing the water into fine spray, which became active centers of condensation.

As yet no great number of tests of air have been made under different conditions, natural or artificial, but in the following table will be found some of the results obtained by this method of counting:

Dust Particles in the Atmosphere.

Source of the air.	Number per c.c.	Number per c. in.
Outside air, raining	32,000	521,000
" " fair	130,000	2,119,000
Room	1,860,000	30,318,000
" near ceiling	5,420,000	88,346,000
Bunsen flame	30,000,000	489,000,000

In the first column of the table is entered the source of the air, in the second the number of particles per cubic centimeter, and, for the benefit of those who think in English measures, the number per cubic inch is entered in the third column. The first number in the table, for ordinary outside air, was obtained on January 25, after a wet night. The number given for fair weather is an average got when the weather was in that condition. As yet far too few measurements have been made to enable us to trace any connection between the number of particles and the weather, but it is hoped that something practical may result from observations of this kind. The first number given for the air in a room is the number counted in the air of a room where gas was burning, and taken at a height of four feet from the floor. The other number was counted in air drawn from near the ceiling, and the last number was got in the air collected over a Bunsen flame.

The value of numbers given in the table has not been carefully considered, and they are not given as absolutely correct. Great accuracy, indeed, does not seem possible when we consider the conditions, and, further, the number is constantly varying. For this reason it has not been thought necessary to make any corrections for temperature and pressure. Though we can get with a fair degree of accuracy the number of particles in the air in the test receiver, yet in all probability the calculated numbers given in the table are rather under than over estimates, as it is difficult to manipulate air without losing much of its dust. For instance, in one hour about one-half of the particles settle out of the air in the gasometer. Though the numbers do seem very large, yet so far as can be judged at present they are fairly correct, and at least represent the kind of numbers we have to deal with. It does seem strange that there may be as many dust particles in one cubic inch of the air of a room at night when the gas is burning as there are inhabitants in Great Britain, and that in three cubic inches of the gases from a Bunsen flame there are as many particles as there are inhabitants in the world.

JOHN AITKEN.

TOBACCO CULTIVATION IN MEXICO.

THE manufacture of tobacco in Mexico into cigars and cigarettes is of comparatively recent origin, dating from the Cuban insurrection of 1868, when a number of refugees from that island landed in Vera Cruz, and there established factories for the manufacture of cigars and cigarettes of the tobacco of the country. Since that time factories have been established in all parts of the republic where tobacco is produced, and the tobacco industry is now, it is stated, furnishing employment for many laborers and skilled workmen. Vera Cruz, says Consul Mackey, of Nuevo Laredo, contained in 1886 four important factories for the manufacture of tobacco, "La Union," "La Especial," "La Prueba," and "La Nacional," besides various establishments on a smaller scale. These four factories employ among them more than a thousand workmen. In San Andres Tuxtla, there are ten factories of the first order, three in Jalapa, and many in Orizaba, Puebla, San Luis Potosi, the city of Mexico, and elsewhere. The factories produce cigars of all qualities, ranging in price from £4 to £40 per thousand. Cigars are manufactured of every size and every shade, and it is said that great ingenuity and taste are displayed in devices of shape and ornament to attract the eye of the smoker. The Valle National, situated between the States of Vera Cruz and Oaxaca, produces tobacco of the finest quality, and is entirely devoted to that purpose. The tobacco of San Andres Tuxtla, Acacuyan, Jathpam, and other portions of the same region, is of excellent quality. Tlapacoyam produces large quantities of tobacco of a class inferior to that grown on the Gulf coast, although the wrappers of Tlapacoyam are much esteemed for their smoothness and fineness in texture. Tobacco of an inferior quality is raised in Orizaba, Chiapas, Cordova, and Oaxaca. The price of tobacco in the leaf, for wrappers and filling, varies in different localities, ranging for filling from four to fifteen dollars, and for wrappers from ten to thirty dollars the arroba of twenty-five pounds. The lands especially adapted to the cultivation of tobacco, the best *vagas* as they are termed, are low, situated in valleys or on the banks of rivers and of easy irrigation. Frequent rains and a humid atmosphere are valuable agents in producing abundant and good crops. In cultivating tobacco in Mexico the following is the method of procedure: The ground is first broken with a species of hoe, and ridges are formed for the reception of the seed, of sufficient breadth to admit of their being cleaned with facility. The stubble is burned or removed, and the trenches are then opened or cleared, in order that the water used in irrigation may circulate freely. The soil having been moistened, a clear day is chosen for sowing, which is done broadcast, care being taken to scatter the seed evenly and equally. In some localities the seed is mixed with fine sand or ashes, which are said to protect it from the attacks of certain insects, and to promote the growth. The shoots sometimes appear in from eight to ten days. Where rain is scarce it is necessary to water the plants, which should be done early in the morning, or in the evening. The shoots are ready for transplanting when they have attained the size of the ordinary lettuce. In their removal, attention is given that the earth adhering to the roots of plants should not fall upon the leaves of others, as this produces a disease called the *pulguilla*, staining the leaves, and destroying the active principle of the tobacco in those places where it is deposited. The season for transplating, like that for sowing, varies according to the climates of the respective localities, it being sought always to gather the crop before the arrival of the frosts. The ground is subject to several plowings, at intervals of from ten to twelve days, and the ditches are opened by which the fields are irrigated. That the excessive humidity of the soil may not injure the plants, they are set either on the ridge or in the side, and not in the middle of the furrow. A hole is made for the reception of the plants by means of an iron instrument, and in each receptacle is placed a plant, or two if they happen to be feeble. If the heat of the day is not excessive, those who set out the shoots follow immediately the laborers, who open the ground with their iron planters. For this reason cloudy days are preferred for transplanting. In setting out the shoots the earth is pressed carefully around the roots, and leveled, so as to leave no inequality where water may settle. About twenty days after the transfer of the plants, the fields are weeded, and plants which have withered or died are replaced by others of the proper growth. When the plants have attained the height of from fourteen to sixteen inches, the lower leaves are removed, and fresh earth is packed about the base of the stalk. The next operation in the cultivation of tobacco is the *capazon*, or pruning of the plants, which consists in cutting away the tops to prevent florescence. This is said to be an operation of such delicacy that upon the skill with which it is performed often depends the good or bad result of the crop. According to the authorities in tobacco culture, the *capazon* is made by grasping firmly the stem of the plant, so that in cutting upward the roots may not give way, and then with a knife removing the top above the joint, where the last leaf joins the stem.

The two or three lower leaves are cut away, for these are worthless and absorb the sap to the prejudice of the others. When the leaves arrive at maturity, they become smooth and lose the down with which they are covered. They are then gathered, and this operation is effected on clear days and after several hours of sunshine. After the leaves are harvested, the plants are cut six or eight inches from the ground, the earth is again loosened about the roots and watered afresh. Thus a second and often a third harvest is obtained. In curing, the leaves are subjected to several processes before being sent to the factories. After being spread in the sun for some time, they are strung together and suspended in a house constructed for the purpose. In order that the fermentation should not be too rapid, the leaves are not allowed to touch each other. After three or four days, the leaves are separated and allowed to dry slowly, it being desired that the color of the veins or stems should be the same as that of the other portions of the leaf. In the process of curing, the leaves perspire, and it is necessary that the curing places should be well ventilated, and that excessive heat should not produce such great fermentation as to be injurious. After the curing is completed, the leaves are separated and distributed in classes according to the custom of the locality; they are then packed for market. If after packing the slightest fermentation is noticed, the bales are reopened and exposed to the air until all fermentation disappears. When the leaves are too moist, they are exposed to the danger of rotting in the bundles; if too dry, they want flexibility, and break in the process of manufacture. Consul Mackey says, in conclusion, that the tobacco of Mexico is of such excellent quality that it is said by many to equal that of Cuba, and there is no doubt among those acquainted with Mexican tobacco that such a comparison is admissible.

PUTREFACTIVE ORGANISMS.

At the recent annual meeting of the Royal Microscopical Society, the Rev. Dr. Dallinger, F.R.S., concluded a term of four years' presidency, and was cordially thanked by the fellows. During his presidency he has been indefatigable in his attendance at the society's meetings, and his presidential addresses have been of great value to microscopy and to biology.

The subject of the major portion of the address was the cycle of putrefactive organisms now beginning to be understood. There can be no longer any doubt that the destructive process of putrefaction is essentially a process of fermentation, and that the fermentive organism is as absolutely essential to the setting up of destructive rotting or putrescence in a putrescible fluid as the yeast plant is to the setting up of alcoholic fermentation in a saccharine fluid. A sterilized solution of proteine in absolutely purified air will remain for any length of time without trace of decay; while inoculation with the slightest atom from a putrescent source will shortly cause turbidity and putrescence throughout. It has been commonly supposed that the exciting fermentive agency is wholly bacterial. No doubt the leading agency of this kind is *Bacterium termo*, and it is impossible to find a decomposing proteinaceous (or albuminous) solution at any stage without finding this form in vast abundance. But in following the processes of destructive fermentation in large masses of tissue lying in water at an average temperature, it is seen that the destructive process is the work, not of one organism, but of many, and that they succeed each other in a remarkable manner. Apparently each set in turn take up the work at a particular stage, feed and develop after their kind, carrying on the destructive process, and at the same time giving rise to conditions suitable for the immediate successor in the cycle; and there is an adaptation of form, functions, mode of multiplication, etc., to the conditions at that stage. The aim of nature in this action is the ultimate setting free of the elements locked up in large masses of organic tissue, and so sending back into nature of the only material of which future organic structures can be composed. Beginning with *Bacterium termo*, this minute creature appears in the fluid surrounding a piece of decaying flesh or fish and increases with astounding rapidity, clothing the tissue as with a skin, noxious gases being at the same time thrown off. In the course of a week or more, dependent on the period of the year, there is usually a development of spiral forms, which likewise invest the rotting tissues, but are always in movement. These bring about a softness and flaccidity in the decomposing tissues. After this a further series of organisms arises, one of a limited set of putrefactive monads of which Dr. Dallinger has specially investigated the life history. They multiply with astonishing rapidity, and by some concurrent changes the decaying mass becomes more and more yielding. These are followed by other forms that at first swim and gyrate and glide about in the decomposing matter. One of these forms, *Heteromita rostrata*, has a long fiber or flagellum that gracefully trails after it as it swims. At certain periods of its life this form anchors in countless billions all over the fermenting tissues, and coiling the fiber bring the body to the level of the point of anchorage, and then shoot it out with lightning-like rapidity, bringing it down like a hammer on some point of the decaying mass. It rests for a second or two, and then repeats the process. This goes on with a sort of rhythmic movement all over the rotting tissue, and the result is to gradually break it up and cause it to disappear. Other forms are known which do similar work, some even more powerfully. In a period varying from one month to two or three the entire mass of organic substance with which we started has disappeared and the decomposing fluid is exhausted, nothing being left in the vessel but slightly noxious and pale gray water, charged with carbonic acid, and a fine buff-colored impalpable sediment at the bottom. Thus Dr. Dallinger is led to conclude that the most important of all ferments, that by which nature's dead organic masses are removed, is complex, and includes the successive vital activities of a series of adapted organisms which are forever at work in every region of the earth. Our acquaintance with the detailed changes thus brought about is but imperfect as yet, and the view thus sketched opens out a large field for research which may have most important sanitary bearings. Toward the conclusion of his address Dr. Dallinger referred to the vital processes of the very simplest and lowest life forms as being as much directed and controlled by immutable laws as the most complex and elevated. "The irrefragable philosophy of modern biology," said the president, "is that the most complex forms of living creatures have derived their complexity from slow and progressive variation and survival from the simplest forms. If, then, these simplest forms of the present and past were not governed by the same accurate laws of life, how did the rigid certainties that govern the more complex come into play?" Consequently there is no room in philosophy for, as there is no fact really supporting, the supposed transformations of one kind of animal into another *per saltum*. Dr. Dallinger is succeeded in the presidency by Dr. C. T. Hudson, well known for his researches on *Rotifera*.

ARTIFICIAL SILK.

An artificial silk is prepared by De Chardonne by dissolving 3 grms. nitro-cellulose in 100 to 150 c. c. of a mixture of equal parts of alcohol and ether. 2·5 c. c. of a filtered 10 per cent. solution ferrous chloride in alcohol, or of stannous chloride, and 1·5 c. c. of a solution of tannic acid in alcohol are then added. The filtered liquid is placed in a vertical reservoir, having at its bottom a blowpipe nozzle of glass or platinum. This pipe forms an acute cone with an orifice of from 0·10 to 0·20 mm., the thickness of the margin not exceeding 0·1 mm., and opening into a vessel of water acidulated with one-half per cent. of monohydrated nitric acid. The level in the reservoir being some centimeters higher than in the vessel of water, the outflow proceeds easily. The fluid hardens at once in the acidulated water, and may be drawn out by a uniform movement in the form of a thread, which must be dried rapidly by traversing a current of dry (not hot) air, and may be wound up as soon as dry. Soluble coloring matters may be introduced into the solution, so as to obtain threads of all colors.

AN APPLICATION OF STATIC ELECTRICITY.

Mr. Wimshurst, the inventor of the induction machine, has applied the latter very ingeniously to the illumination of bodies having a rapid motion.

The following experiment will make the application under consideration understood. If, at a velocity of several thousand revolutions per minute, we revolve a disk upon which there is printing in small characters, and if a series of sparks be passed at the moment that the characters are in a vertical position, the printed portion can be read.

To succeed in this, it is necessary to have a commutator that makes the sparks start from the machine at the desired moment, and this would naturally be done by actuating the commutator through the revolving disk. It would be possible in this way to examine a rapidly revolving wheel, and this in certain cases might prove useful.—*La Lumiere Electrique.*

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of The Supplement, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of The Supplement can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

Combined Rates.—One copy of Scientific American and one copy of Scientific American Supplement, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

388.

ent.

s in any
ollars a

rom the
Price,

can like
yearly,
or $8.50

AMERI-
SUPPLE-

nts, and

N. Y.

PAGE

merican,
ican and
ence, and
e world.

Ameri-
Agency.
By the
ention is
l sales or

or inven-
a patent
N & Co.
e Patent
costs, and

York.